LEVEL II (1) (8)

SRI Project 2358

Technical Note
SSC-TN-2358-2

June 1975
Final

DEFENSE R&D ISSUES: THEIR IMPORTANCE IN LONG-RANGE STRATEGIC PLANNING

By:

JOHN J. FORD
COLIN S. GRAY
JEROME E. JACOBS
WILLIAM F. LACKMAN, Jr.
WILLARD W. PERRY
GENERAL ROBERT C. RICHARDSON
FRANK H. TRINKL
RONALD C. WAKEFORD

Prepared for:

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
1400 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22209

CONTRACT ~~DAHC15-73-C-0183~~
ARPA Order No. 2289

Approved for public release; distribution unlimited

STRATEGIC

STUDIES

CENTER

STANFORD

RESEARCH

INSTITUTE

STRATEGIC STUDIES CENTER

SRI PROJECT 2358

Technical Note
SSC-TN-2358-2

June 1975
Final

DEFENSE R&D ISSUES: THEIR IMPORTANCE IN LONG-RANGE STRATEGIC PLANNING

By: JOHN J. FORD
COLIN S. GRAY
JEROME E. JACOBS
WILLIAM F. LACKMAN, Jr.
WILLARD W. PERRY
GENERAL ROBERT C. RICHARDSON
FRANK H. TRINKL
RONALD C. WAKEFORD

Prepared for:

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
1400 WILSON BOULEVARD
ARLINGTON, VIRGINIA 22209

CONTRACT DAHC15-73-C-0183
ARPA Order No. 2289

Approved:

Richard B. Foster
Strategic Studies Center

Approved for public release; distribution unlimited.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER SSC-TN-2358-2	2. GOVT ACCESSION NO. AD-A107747	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DEFENSE R&D ISSUES: THEIR IMPORTANCE IN LONG-RANGE STRATEGIC PLANNING		5. TYPE OF REPORT & PERIOD COVERED Technical Report
		6. PERFORMING ORG. REPORT NUMBER N/A
7. AUTHOR(s) John J. Ford, Colin S. Gray, Jerome E. Jacobs, William F. Lackman, Jr., Willard W. Perry, Gen. Robert C. Richardson, Frank H. Trinkl, Ronald C. Wakeford		8. CONTRACT OR GRANT NUMBER(s) DAHC15-73-C-0183 ARPA Order No. 2289
9. PERFORMING ORGANIZATION NAME AND ADDRESS Stanford Research Institute, Strategic Studies Center, 1611 N. Kent Street, Arlington, VA 22209		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS SRI Project 2358
11. CONTROLLING OFFICE NAME AND ADDRESS Defense Advanced Research Projects Agency 1400 Wilson Boulevard Arlington, Virginia 22209		12. REPORT DATE June 1975 13. NO. OF PAGES 245
		15. SECURITY CLASS. (of this report) Unclassified
14. MONITORING AGENCY NAME & ADDRESS (if diff. from Controlling Office) Defense Supply Service-Washington Room 1D245, The Pentagon Washington, D.C. 20310		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this report)

Approved for Public Release; Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from report)

N/A

18. SUPPLEMENTARY NOTES

N/A

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

NATIONAL DEFENSE
RESEARCH MANAGEMENT
STRATEGY
SECURITY

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report reviews the key issues associated with defense technology to provide a basis for the examination of R&D policy and the formulation of program plans. The issue papers examine the concepts of technological superiority, balance, and surprise; discuss technology in negotiations and international cooperation in R&D; and assesses selected R&D aspects of military strategy and planning.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

19. KEY WORDS (Continued)

20 ABSTRACT (Continued)

DD FORM 1 JAN 73 1473 (BACK)

EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ABSTRACT

This report reviews the key issues associated with defense technology to provide a basis for the examination of R&D policy and the formulation of program plans. The issue papers examine the concepts of technological superiority, balance, and surprise; discuss technology in negotiations and international cooperation in R&D; and assesses selected R&D aspects of military strategy and planning.

DISCLAIMER

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Defense Advanced Research Projects Agency or the U.S. Government.

CONTRACTUAL TASKS

This Technical Note is in partial fulfillment of Contract DAHC15-73 C-0183.

FOREWORD

This study is an element of the research program for the Defense Advanced Research Projects Agency (ARPA) and is concerned with an investigation of R&D issues. It is a complimentary task to such other ARPA sponsored research as studies of Soviet strategy, technology transfer, and RDT&E planning. The research centers upon analysis of the key R&D issues which surround program planning and often impact the implementation of various efforts. The scope of the study required both a broad understanding of technology and the processes by which defense R&D policy is formulated. Accordingly, a select group of authors knowledgeable in one or more R&D problem areas were selected to author the various issue papers.

The principal investigators were M. Mark Earle, Assistant Director, SSC and Ronald C. Wakeford, Senior Operations Analyst. The authors of individual issue papers are identified in the report.

Richard B. Foster
Director
Strategic Studies Center

CONTENTS

III ISSUE PAPERS (Continued)

FIGURES

TABLES

I INTRODUCTION

Continued change in the global political, economic, and military environment makes it important that the present issues surrounding the defense R&D program be investigated to identify needed changes in either the planning or implementation of the program. The major changes in the R&D environment include:

- The rapid progress made over the past decade by the USSR and PRC in military technology and accompanying U.S. concern for the possibility of a technological surprise.
- Disagreement as to whether U.S. technological superiority in all military R&D fields is either attainable or necessarily desirable.
- New knowledge of technological applications based on the results of advanced weapon tests in the combat environment of the Middle East.
- Increased uncertainty as to the appropriate role of technology in devising arms and force control agreements.
- An extensive shift in U.S. public and Congressional attitude toward defense and military technology.
- A deterioration in the partnership role of allies at a time of increased need for cooperation.
- Deterioration in the national and allied economies, increasing inflation, and trends toward a diminishing defense R&D budget.
- A growing problem of basic resource scarcities including energy, raw materials, manpower, and facilities.

These factors and others made it desirable that the current R&D issues be examined to discern pros and cons, and to assess the strengths and weaknesses of the various arguments. To this end, papers have been prepared on ten issues that tend to dominate discussions of the R&D environment. Summaries of the principal findings are presented in Chapter II; the complete papers are contained in Chapter III.

II SUMMARY OF R&D ISSUE PAPERS

The R&D issues selected for scrutiny were chosen from those considered to impact most heavily on the resolution of military force decisions for the 1980s. Secondarily, the issues discussed were selected because of their relationship to the political, economic, and psychological concerns emerging in both the national and international environment. Considerations of the political and psychological consequences of an adverse technological surprise have been raised as has an assessment of the economic burdens of continued technological supremacy. Key questions as to the political-economic viability of existing R&D planning mechanisms have been introduced into several of the papers; these include those addressing issues of cooperative R&D with allies, Soviet planning implications, the net technical assessment, and R&D planning alternatives. The political role of technology as a bargaining chip in attaining arms and force controls, and in facilitating the successful relief of international tension, has been investigated to disclose issues regarding the relative merits of this approach to negotiations.

The individual summaries of papers have been grouped into four categories; these are: (1) technology issues which introduce such subjects as technological superiority, balance, and surprise; (2) political-economic issues which encompass a scrutiny of the role of technological developments in furthering arms and force control, and a review of how international cooperation in R&D might be enhanced; (3) R&D strategy issues, involving an analysis of offensive U.S. defensive developments and consideration of the technological contribution to dual capable forces; and (4) R&D planning issues which focus upon Soviet R&D, net technical assessment, and alternative planning guidelines.

A. Technology

1. Technological Superiority--Is It a Viable Defense R&D Objective?

In spite of the need for U.S. superiority in defense technology, the technological lead which the United States has enjoyed over the USSR is diminishing. In the current economic climate in the United States, resources for defense R&D are limited; therefore the Department of Defense must look to other sources for technological development. One of these sources, U.S. consumer technology, would be a logical focus of attention, for therein lies a great advantage to the United States over the Soviet Union. The U.S. industrial base provides a vast pool of scientists, technicians, and managers seeking new products and finding more efficient ways of producing them--a pool that produces improved military equipments as well as civilian consumer products. It is essential in today's environment for U.S. defense planners to seek ways to enhance the development of this consumer-generated, defense-related technology. To accomplish this, the DOD should undertake programs to reduce the classification of military technology, to increase the awareness by industry of military needs, to use industry more freely in military logistics and other similar programs, and to more closely couple American military technology to the civilian consumer industry.

2. Technological Surprise and Defense R&D Planning

A review of past technological surprises reveals that every one of them could have been prevented with better planning. To determine the feasibility of technological surprise today, it is necessary to establish what kind of technical innovations could severely weaken our defenses. With regard to the U.S. strategic deterrent forces, the Soviets could render them ineffective by (1) destroying the deterrent weapons before they are launched (first strike); (2) destroying the warheads in flight (ballistic missile defense--BMD); or (3) a combination of first strike and BMD.

The only realistic way that the United States could incur a scientific surprise would be from indecisive or short-sighted defense planning on the part of the United States, and not from a surprise discovery or a surprise application by the Soviets. To avoid this outcome, the United States must (1) maintain an adequate scientific and technological base, (2) understand the potential of science and technology, (3) understand the needs of technology, and (4) develop required technologies. This can be achieved by improving the dialogue between the creative weapons system analyst and the scientist or technologist, by broadening the scope of industry participation in the defense effort, and by establishing a separate DOD agency to coordinate and integrate all activities for determining technology needs for avoiding technological surprise.

3. Technological Superiority Versus Technological Balance

U.S. maintenance of technological superiority over the Soviet military has been an implicit objective of the United States for many years. Recently, however, as economic and political pressures call for a more precise defense planning, it has become clear that the concept of technological superiority needs to be defined more carefully than in the past. An alternative concept--that of technological balance--is now under consideration. This concept implies that we are in a technology race which is a dynamic process, but it would also allow an opportunity for restraint on the part of competing countries. Superiority in weapon performance, however, is not the measure of merit of dominant interest. It is the combined performance of many weapons that determines the ultimate objective--superiority in force effectiveness. This might be achieved through a selective superiority in certain weapons and parity or even inferiority in others.

A basic ingredient, however, is necessary to maintain a technological balance. This is technological base superiority. This base is composed of two parts, only one of which involves the defense R&D effort. The other part is the general national technology base composed of all

scientific and technological activities. Currently the United States enjoys a clear superiority over the Soviet Union in this regard, and there seems little danger of our being overtaken. This superior technological base would enable the United States to pursue an R&D rationale of general technological balance and selective technological superiority.

B. Political/Economic

1. Bargaining Chip--A Proper Rationale for Defense R&D

"Bargaining chip," a concept that comprises part of what is generally understood as bargaining power, has always been an inherent feature of negotiating contexts. It is only recently, however, that this concept has acquired the dignity of being singled out as a distinctive "approach" to arms control negotiations. Critics of the bargaining chip approach to SALT offer arguments against it that in many cases are poorly articulated attitudes that hide their basic unwillingness to face political reality. An important reason why the bargaining chip rationale for acquiring new weapons systems has attracted critical attention is that the United States has not had a clear strategic doctrine to which new weapons would obviously relate. It has also seemed to many that the bargaining chip rationale has been introduced as a desperation measure to rescue analytically dubious systems that were in serious trouble.

The major problems in relation to which U.S. bargaining chips acquire their market value are the following: the vulnerability of the land-based missile and bomber forces; the maintenance of an essential equivalence of counterforce capability; and political perceptions of the state of and likely future movement in the central strategic balance. One should pursue to the point of deployment only those systems which one believes will work within acceptable limits of performance. One should pursue only through development and testing those systems that contribute significantly to the maintenance or useful enhancement of strongly desired capabilities. Finally, one should analyze very carefully

indeed exactly what the relationships are between the systems in question and the guiding doctrine.

2. International Cooperation in R&D--How Can It Be Achieved?

The economic conditions in both Europe and the United States have given renewed impetus to the drive for standardization through the medium of cooperative R&D. The major issues to be resolved are dominated by the need for joint R&D planning either within a revitalized and decisive NATO organization, or trilaterally with the U.S., UK, and West Germany. Planning with the more modestly endowed R&D performers of Europe could be deferred until the principal partners had resolved differences. Cooperative R&D planning, when appropriately juxtaposed with U.S. technological base and mission planning, could serve as a basis for the reformulation of domestic defense R&D plans. In addition, this effort if consolidated and appropriately staffed within DOD could replace the ad-hoc multiorganization efforts and, over the long term, provide a sound basis for compatible military, political, and economic strategies within the Alliance.

Requirements issues, particularly those involving degree of sophistication of weapons and equipments, have continued to cause difficulty in harmonizing needs. Further efforts to define the differing levels of sophistication needed for U.S. weapons and equipments serving a global role, as against a more limited European combat scenario, are essential. A modular approach to the specification of U.S. weapons and equipments offers some promise. Effective cooperative efforts during or at the close of the advanced development cycle are a key to future standardization. Once projects have entered engineering development, it becomes extremely difficult to negotiate change and consolidate requirements. The advanced development stage of R&D provides an appropriate pause in the progress toward systems deployment, and offers an opportunity for negotiating differences prior to the incurring of heavy cost, personnel, and institutional commitments. The economic issues of R&D cooperation will yield to any sensible approach that provides a quid-pro-quo solution.

C. R&D Planning Strategy

1. Offensive Versus Defensive Technology

This study addresses the question of the relative emphasis given in R&D to offensive versus defensive weapons systems in the general purpose forces. Most U.S. R&D efforts cannot be identified with advancing either offensive or defensive capabilities--particularly in the general forces area--primarily because most R&D programs serve to advance both capabilities. The favoring of offensive or defensive force capabilities on the basis of "lessons learned" or of "changing operational requirements" can only be done in timely fashion by making selections from new technologies and new weapons ready to go into production. This suggests that the problem of emphasis on offensive versus defensive capabilities in the area of R&D is one of system selection for deployment rather than one of R&D orientation.

No nation can pursue "responsive" RDT&E policies and hope to maintain an adequate level of national security. Technological base programs of the United States should not be influenced or limited by treaty, moral, arms control, or other similar and possibly nonpermanent manmade constraints. Since "responsive R&D" means that the United States will not initiate new weapon development programs, or pursue new defense technologies, except in response to identified efforts in these areas by others, such a policy can only lead to technological inferiority in all areas due to a combination of leadtime and difficulty in obtaining intelligence in this area. The argument, therefore, that aggressive R&D undertaken independently of identified new threats is provocative of arms races--while possibly true--must be rejected on the grounds that the alternative is technological and eventual military inferiority.

2. The Deterrent Role of Dual Capable General Purpose Forces--The Technological Contribution

The advent of strategic parity, the pressures toward nuclear proliferation, the increasing sophistication of the modern battlefield, and

the likelihood that the armed forces of the United States and its allies will be faced with numerically superior and increasingly heavily armed opponents demands a deterrent posture based on a credible dual-capable force. The application of precision-guidance techniques to a wide range of systems--artillery, antitank missiles, bombs, and rockets--offers the possibility of improved conventional effectiveness with lower manpower densities, thereby affording a measure of passive protection against enemy use of nuclear weapons. PGMs also offer promise of using tactical nuclear weapons with greater effectiveness and selectivity, thereby reducing collateral damage.

A posture that couples the precision-guided conventional munitions, the reduced battlefield troop densities, and the improved conventional warheads that are already with us with small tailored-effect tactical nuclear weapons would constitute a truly dual capable force. Such a force would not only raise the nuclear threshold, but also, more importantly, have a synergistic effect on the deterrence of both nuclear and nonnuclear aggression. The uncertainty of success felt by a potential aggressor coupled with the uncertainty of escalatory risk represented by his opponent's credible nuclear capabilities will add to the stability of areas of possible conflict such as Europe.

D. R&D Planning

1. Soviet R&D: Implications for U.S. R&D Planning

It is almost certain that the United States will have to respond in the future to Soviet strategic initiatives derived from the research of the institutions and groups that have been mobilized to "secure a victory over capitalism." In anticipation of this contingency, it is incumbent upon the U.S. intelligence community and the R&D planners it informs to broaden their perspectives and address the activities of, for example, social science research establishments as a first step toward adaptation of our strategic responses to those anticipated Soviet initiatives. It

is conceivable that a variety of appropriate counterstrategies would be evolved thereby by the United States to what could otherwise be a series of strategic surprises. Organizational structures and functions appropriate to the task of reflecting patterns of interactive Soviet research activity may also be evolved.

Adaptation of our threat-response structures and behaviors, as President Ford has advised, to meet all of the challenges portended by the Soviet R&D strategy in this era of interdependence is implied by Soviet R&D. Because of the knowledge gap and institutional inertia it would be foolhardy to attempt to conceptualize adaptive structures and processes for the future on the basis of theories and organizations contrived during the era of independence. The terrain of interdependence is relatively unexplored, hostile and a potential source of unexpected, mind-boggling surprises. But it must be crossed step-by-uncertain-step on the way to a mastery of complexity.

2. NTA Methodology--Its Value in R&D Planning

Sword-on-shield NTA, because of its use of an independent threat definition and because of its ability to identify which technical features should be emphasized to enhance mission effectiveness, provides the most realistic method of establishing a priori definitions of development goals and technical parameter trade-offs, should cost or schedule constraints limit the choice. Sword-on-shield NTA also provides guidance in determining correct "blend" of technical performance characteristics and provides a performance criterion both for the design of test and evaluation experiments and for rational decisionmaking when the number of viable options must be limited. Side-by-side NTA is useful in directing the program thrust in the research and exploratory development categories. It is in the effective implementation of this principle that NTA can make its greatest contribution to R&D planning.

Although the use of NTA has been considered expensive, the alternative is to make far-reaching decisions on the basis of judgment or

opinion alone. The use of NTA contributes to judgment and in the process builds an analytical case which will enable shorter response time, with consequent cost reduction. When time constraints do force a resort to judgment, use of the analytical base should produce more effective decisions.

3. <u>Alternative Guidelines for RDT&E Activities</u>

Although the analysis presented is not a comprehensive one, several concluding observations can be drawn. First, the adoption by the United States of a measured response R&D strategy appears to be a desirable choice. Guidelines for the implementation of this strategy are relatable to potential deployment classes. The implementation of such a strategy offers distinctive prospects for influencing Soviet R&D activities. Should the strategy be jointly adopted by both the United States and the Soviet Union, prospects for achieving comprehensive controls over the quality of strategic forces could be enhanced; moreover, prospects for reaching potential agreement covering nonstrategic forces could also be enhanced.

A U.S. strategy of technological superiority, although a desirable strategy from the U.S. viewpoint, cannot but compel the Soviet Union to allocate increasing expenditures to military R&D so that the technological gap presently existing is not exacerbated. Unless there is restraint shown in the Predeployment System process, prospects for controls on the qualitative character of forces are less than fully certain. Should both the United States and the Soviet Union strive for technologically superior advanced systems, it is highly unlikely that qualitative restraints on future force deployment could be achieved. An R&D planning strategy based on measured response concepts could contribute to controlled R&D expenditures; more importantly, it offers prospects for influencing such expenditures within the two countries.

SOVIET R&D: IMPLICATIONS FOR U.S. R&D PLANNING

by

J. Ford

SOVIET R&D: IMPLICATIONS FOR U.S. R&D PLANNING

SUMMARY

It is almost certain that the United States will have to respond in the future to Soviet strategic initiatives derived from the research of the institutions and groups that have been mobilized to "secure a victory over capitalism." In anticipation of this contingency, it is incumbent upon the U.S. intelligence community and the R&D planners it informs to broaden their perspectives and address the activities of, for example, social science research establishments as a first step toward adaptation of our strategic responses to those anticipated Soviet initiatives. It is conceivable that a variety of appropriate counterstrategies would be evolved thereby by the United States to what could otherwise be a series of strategic surprises. Organizational structures and functions appropriate to the task of reflecting patterns of interactive Soviet research activity may also be evolved.

Adaptation of our threat-response structures and behaviors, as President Ford has advised, to meet all of the challenges portended by the Soviet R&D strategy in this era of interdependence is implied by Soviet R&D. Because of the knowledge gap and institutional inertia it would be foolhardy to attempt to conceptualize adaptive structures and processes for the future on the basis of theories and organizations contrived during the era of independence. The terrain of interdependence is relatively unexplored, hostile and a potential source of unexpected, mind-boggling surprises. But it must be crossed step-by-uncertain-step on the way to a mastery of complexity.

SOVIET R&D: IMPLICATIONS FOR U.S. R&D PLANNING

A. Purpose

The purpose of this paper is to examine some of those issues arising from the research and development strategy of the Soviet Union which could have serious implications in terms of future R&D plans of the United States.

B. Background

A growing body of evidence suggests that the R&D strategy of the Soviet Union is "pulled," i.e., determined by that nation's policies. The latter, in turn, are influenced strongly by the world-view dominant in the Soviet Union and by its accompanying perceptions of the relative places of capitalist and socialist forces in the contemporary world situation. The R&D strategy resulting from these and other influences raises a very serious issue for formulators of the "counter" strategies of the United States: To avert Soviet-prompted strategic and technological surprises, R&D planning by the United States will have to consider the determining role of national policy in the R&D strategy of the Soviet Union.

The prevention of strategic and/or technological surprise, one raison d'etre of an R&D strategy, is unlikely if the "push" approach is favored in the United States while opponents' national policies and strategies are neglected. This issue is raised to cast some light on the latter with the hope that U.S. R&D planners may be prompted, thereby, to consider alternative strategies to the "push" variety that may be more responsive to especially anticipated future states of the world system, as the latter may be influenced by the implementation of Soviet R&D strategies. A

secondary purpose is to illustrate how anachronistic the results of a "push" strategy would be under certain future global conditions.

Due to the advent of weapons of mass destruction and to an increased awareness of global interdependencies, the nature of competition is undergoing a fundamental transformation in the contemporary era. As the threat of contests between nations' arms gives way to struggles for survival between different systems of social organization, traditional military research and development programs become but one among many facets of global, systemic competition. By way of example, the function of control in weapon systems offers challenge in the older mode, but it is now but one aspect of a much more comprehensive control research and development program of which the overall object is the management of large, complex, purposive systems be they technological or social. Unfortunately, current U.S. strategy for R&D does not reflect sufficient awareness or concern for these and related Soviet efforts to develop and implement plans to employ what is referred to in the USSR as "the contemporary revolution in science and technology" to advance their complexity-management capabilities on a scale consonant with the global requirements for intersystemic competition. Obviously, the thesis raised in this "issue" would have serious implications for U.S. R&D planning.

C. Statement of the Problem

The problem for U.S. planners implied by the Soviet R&D issue has three interrelated facets:

- A U.S. R&D strategy purporting to be responsive to the anticipated threats portended by current research and development in the Soviet Union would have to be based on a profound understanding of the global policy of the USSR which "pulls" that R&D program.
- From what we have learned about it, that global policy is based upon certain assumptions concerning international dynamics which are quite alien to and more comprehensive than Western concepts concerning modes of competition between nations. The R&D program

"pulled" by the global policy of the USSR stands to be equally alien and comprehensive relative to the U.S. R&D strategy "pushed" as the latter tends to be by the internal dynamics of the more traditional defense systems. The resulting situation is one rife with possibilities for technological surprise as the course of intersystemic competition unfolds.

- To lessen, if not to preclude, the probability of technological surprise, the R&D strategy of the United States and the paradigm from which it is derived will have to be adapted to the systemic realities of the 1970s. This is the major implication of Soviet R&D for U.S. R&D planning.

D. Discussion

The R&D strategy of the USSR is "pulled" by a policy based upon the belief that the nature of competition in the contemporary era is being transformed from simple contests of arms between nations to one between systems of social organization to determine not which is the stronger but which is the optimal variant in the process of social evolution. Thereby, the strategic context is raised in this Soviet paradigm from the rather simplistic level of superpower interactions to one embracing intersystemic global reality.

New modes of thought must be evolved to handle the new level of complexity characteristic of this reality. As the elements of global society interact ever more richly in the future, society will become even more complex. The management of complexity bids fair, therefore, to become a major problem for a new genre of strategists in the era of interdependence. Just as the handling of arms offered challenge in the era of independence, the development and use of means for managing large complex, probabilistic systems stand to become the major contemporary challenges.

Current net-threat assessments neglect Soviet efforts to develop and implement complexity-management capabilities on a global scale. Reports about such efforts tend to be ignored, possibly because they lack correspondence with the more traditional and dominant strategic concepts

adhered to in the United States. Should this attitude persist the possibility of a panoply of strategic surprises in "the competition between the two world systems" would be increased. That competition between capitalism and socialism is cast in evolutionary terms: the system of social organization that can best manage complexity will evolve and grow globally; the system that cannot adapt to the contemporary challenge of complexity will devolve.

There has been a pronounced inclination on the part of Americans to put down the massive Soviet research and development effort to employ "the contemporary revolution in science and technology" in intersystemic competition. Some of the concepts embraced by the Soviet phrase "the scientific and technological revolution" are employed by the United States in the strategic context, although under different rubrics, to resolve the paradoxical situation in which we now find ourselves. We are powerful in those weapons of mass destruction which may never be used, but relatively impotent so far in the face of the nonmilitary threats to global systemic stability and order which are employed currently. The inertia of a disciplinary guild system wedded to a bureaucracy has militated against the adaptation of threat-response behavior to the novel realities apprehended now by both our leaders and many citizens. But with the recognition of the above referenced paradox at least one strategic doctrine seems to be undergoing quantitative rather than a qualitative modification, i.e., the use of strategic forces not for an opponent's destruction but for negating his <u>control</u> function.

Controlled thermonuclear conflict, so called, involves more of a quantitative change in threat response behavior than a qualitative change responsive to the novel challenges to security in this era of interdependence. It is referenced here because of its emphasis on the importance of control functions. If successfully implemented, CTC would impair those control functions upon which the continuance of an opposing society depends. However, the concept does not resolve the paradox; with an

opponent's control system knocked out our lack of capability for handling the problems of systemic instability from unmanaged interdependent networks would remain.

Control of global interdependent networks for supplying the metabolic needs of the world community will be the prize for which the superpowers will compete in the future. Because of our concentration on U.S.-USSR power relations, most strategic thought in the West has not risen to the challenge of this emerging competition.

This competition will not involve contending nation-states but the systems of social organization represented by capitalism and socialism. And it will involve less physical power and more capabilities for the management of complexity. Hence the Sovbloc reference to the so-called scientific and technological revolution as the "center of gravity" in the economic competition between the world socialist system and the capitalist system. At the nub of that "revolution" is the science of communication and control along with its associated technologies such as computers.

The West obviously is intent also on applying this scientific and technological revolution to individual systems of production, distribution and so on. It pulls up short, however, at the level of intersystemic management. But it is at the metasystemic level where subordinate, non-ideological systems would be purposefully managed in accordance with the controller's global designs. This failure of the West to capitalize on its gains toward global economic integration by moving on to the design of a supranational metasystem for the management of complexity constitutes a real, albeit generally unrealized, vulnerability in intersystemic competition.

Sovbloc research and development supportive of such policies and strategies for intersystem competition are not confined to the hardware technology for the management of complexity. By way of example, the activities of the social sciences section of the Academy of Sciences,

USSR, are involved in research on the human dimension of complex systems. Almost totally ignored by U.S. strategic intelligence, the institutes and complex councils under that section have been responsible for the development of strategies for the conduct of intersystemic socio-economic conflict at least since the 1967 CPSU Resolution: "On Measures for the Further Development of the Social Sciences and for Raising Their Role in Communist Construction." This resolution stressed:

> ...the intensification of creative work in the sphere of theory is imperative...to determine the most effective ways and means to secure the victory of socialism over capitalism.[1]

Toward this end, the Soviets have mobilized a considerable research effort involving the Party's Institute of Marxism-Leninism and the Academy of Social Sciences along with institutes of the Academy of Sciences, USSR:

- Institute of World Economy and International Relations (IMEMO)*
- Institute of the Economy of the World Socialist System (IEMSS)
- Institute of Oriental Studies (IV)
- Institute of Africa
- Institute of Latin America (ILA)
- Institute of the International Workers'Movement (IMRD)

---

1 Pravda, pp. 1-2 (8 August 1967).

* The Soviet perspective on international relations is more holistic than its Western counterparts. Their methodological approach is defined in International Relations After World War II (a three-volume work published from 1962-65) as the totality of economic, political, ideological, legal, diplomatic and military contacts and interrelationships between states and systems of states, and between the principal social, economic, and political forces and organizations operating in the international arena. Significantly, my personal contacts with IMEMO researchers revealed an intense interest in the information and control aspects of MNC's among the first 200 corporations in Fortune's top 500 corporations.

- Institute of Scientific Information on the Social Sciences (INION)
- Institute of the United States of America (IUSA)
- Institute of Philosophy

The institutional network in which the Soviets' research and development plans are implemented had to be adapted when the domain of strategic research was enlarged in response to the policy of "systems competition." Taking cognizance of the interdependencies and interrelationships obtaining in the world and the inability of individual regional or discipline-oriented institutes to reflect such complexity, the Soviets started around 1958 to create a set of new interdisciplinary organizations called "complex scientific councils." The activities of these councils are relevant to Soviet efforts to develop "peaceful" strategies for accomplishing their global objectives. One of their jobs is to gain understanding of the institutions and mechanisms through which control of global systems is exercised as in communication and computer networks, and to comprehend the complex patterns of interdependencies and their relationships with the geographical subdivisions in which they are embedded. The most important complex councils relative to the issue propounded in this paper are:

- The Scientific Council for the Complex Problem: Cybernetics
- The Scientific Council for the Complex Problem: The Economic Competition of the Two Systems
- The Scientific Council on the Complex Problem of the Working Class and Mass Democratic Movements in Capitalist Countries in Conditions of the Contemporary Scientific-Technical Revolution
- The Scientific Council for the Contemporary Problems of Developing States
- The Scientific Council for the Complex Problem: Socio-economic and Ideological Problems of the Scientific and Technological Revolution

These councils sponsor conferences on special topics and generate and coordinate relevant research throughout the USSR. An example of the conference activity is an event sponsored by the Council on Contemporary Problems of the Developing States to discuss the impact of the scientific

and technological revolution on developing countries. The cybernetic revolution is seen as a major focus of competition between socialism and capitalism in the Third World.[1] The coordination function is typified by the Council on the Socio-Economic and Ideological Problems of the Scientific and Technological Revolution. It has specific assignments set by the 24th Congress of the CPSU to organically relate the fruits of the cybernetic revolution to the socialist system of political economy. With 67 eminent scientists in economics, philosophy, sociology, law, psychology, history and fundamental natural science its task is to generate and coordinate relevant research from throughout the USSR.[2]

The research of these institutions and groups is likely to lead in the future to rather novel Soviet strategic initiatives to which the United States will have to respond. This contingency must be anticipated by the U.S. intelligence community and by the R&D planners it informs. But for this to be done successfully the perspectives of both must be broadened to accord the activities of social science research establishments in the USSR as well as the work of military-related scientific institutions their due attention. The resultant foreknowledge is a necessary but not sufficient basis for development of a repertoire of responses on our part which is sufficiently rich, at least, to offset the variety of anticipated Soviet initiatives.

Creativity on the part of U.S. research and development strategists is another necessary precondition to a successful response to the imperative posed by Soviet R&D. A future-directed research and development strategy would be quite innovative for planners long inured to strategies of the "push" variety. Creativity is needed to devise a strategy "pulled" by a vision of national purpose, by an awareness of the complex pattern

---

1 M. Volkov, "Science, Technology and Development of the Third World," Social Sciences, No. 1, pp. 163-165 (1974).

2 R. Khasbulatov, "New Scientific Council of the USSR Academy of Sciences," Social Sciences, No. 1, pp. 221-222 (1974).

of interdependencies characteristic of the contemporary world and by other ideational forces as well as by an anticipation of a panoply of threats, military and non-military, from the Soviet Union. Such factors, with the possible exception of anticipated military threats, are not accounted for in R&D strategies "pushed" by the engine of change internal to the process of native weapon systems development.

A major implication of Soviet research and development for the planning of U.S. science and technology is, therefore, this need for a shift on the U.S. side from a "push" to a "pull" strategy. Such a shift would entail a radical reallocation of priorities to research programs because philosophical, economic, psychological, ecological and political problems would have to vie for strategic attention along with such issues as those prompted by Soviet advances in high-energy lasers, in missile guidance, or in nuclear technology.

The Soviets may be doing a favor for us if their current science programs evoke such states of behavior on the part of U.S. R&D strategists. A mixed R&D strategy productive of a rich repertoire of behaviors for responding to altered and complex states of both the national and global environments would be a good thing for the United States, in our estimation, even if the Soviet Union were to disarm unilaterally. Among the premises leading to this conclusion are those suggested by an aspect of game theory dealing with relationships between the complexity of organizational forms and the maintenance of stability in systems embedded in changing environments.

According to this theory a system must react to an external stimulus with one of the methods at its disposal. Systems with a single strategy for maintaining stability respond to all external stimuli with a force directly proportional to the strength of the external influence. It might be said that the development of weapon systems for so employing force is a major objective of the current R&D strategy of the United States.

But there is a second method for achieving dynamic stability. It calls for the matching of each strategy of the environment (opponent) with a new and corresponding counterstrategy. The differences between elicited responses are qualitative rather than quantitative. Survivability in competitive struggles is directly proportional to the number of different strategies that each of the competing systems has at its disposal. That is to say, those systems will tend to be preserved which possess the greater variety of methods of behaving in response to variegated external stimuli.

A relationship is posited also between the richness of the store of methods of behaving and the amount of circulating information in the system. The latter is a quantity dependent upon system organization; systems possessing a variety of strategies or a greater choice of possible responses are likely to have a complex inner structure, that is, a high level of organization. The more complex the system, the greater is the number at it disposal of possible responses to external influences from which to choose. The evolutionary progression of biological and social systems which seems to have followed the path of increasing complication illustrates this facet of game theory.

The process of complication evidenced by the evolution of biological and social systems is accompanied by the development of mechanisms for simplifying or "automating" complex systems. There is no questioning of this thesis in those cases where modern means for delivering or intercepting mass destruction weapons are involved. Automation of such processes is a major component of even "pushed" R&D strategies. It is certainly a key desideratum in the research and development strategy of the USSR "pulled" as it is by the policy-determined exigencies of the intersystemic competion between capitalism and communism. It is part of the hidden agenda behind the rather well publicized Soviet R&D strategy calling for the application of "the contemporary revolution in scientific and technological affairs" in resolving "the competition between the two world systems of communism and capitalism."

E. Summary of Major Findings

The dominant world-view in the Soviet Union is expressed in the national policy of the USSR which is in turn the major determinant of Soviet R&D strategy. To anticipate and to effectively counter the latter, U.S. R&D strategies would have to be similarly influenced by Soviet national policy. The major implication of Soviet R&D for scientific and technological planning in the United States is, therefore, that the latter will have to shift from a "push" to a "pull" approach to avert Soviet policy-prompted, strategic as well as technological, surprises. That is, the traditional research and development, i.e., the dynamics of the R&D system itself, will have to be supplemented by "pull" exerted by such forces as a sense of national purpose and anticipated global futures as well as composite challenges from the East.

Such a shift would involve much more than an administrative decision. The "push" approach to our R&D strategy is an expression in military practice of the more general paradigm of science, society and international dynamics subscribed to by the Western world for several centuries. Before the U.S. R&D strategy can change in the direction implied by Soviet science and technology, this paradigm will have to be adapted to the systemic global realities of the late 1970s. U.S. capabilities for the adaptation of modes of thought to the levels demanded by the complex interdependencies characteristic of today's world are as vital in "this era of competition between the two world systems" as were our military research abilities in times of more simplistic superpower interaction.

Soviet R&D strategy fostering "the contemporary revolution in science and technology" and its application to the competition between the two world systems of capitalism and socialism implies a rather novel set of challenges to U.S. R&D planners. Possible implications include: a shift from a "push" to a "pull" R&D strategy; an adaptation of the paradigm of traditional Western science; an enlargement of the notion of international conflict to embrace intersystemic competition; and the use of the

contemporary revolution in scientific and technological affairs as an organizing principle for a national and, perhaps, an international program of science for survival. The grist here is more than the R&D planning mill has ever taken in before. It is obvious that the U.S. R&D planning system would have to undergo a self-organizing adaptive process to the contemporary global situation in order to respond constructively to the total research and development program of the USSR.

BARGAINING CHIP--A PROPER RATIONALE FOR DEFENSE R&D

by

C. Gray

BARGAINING CHIP--A PROPER RATIONALE FOR DEFENSE R&D

SUMMARY

"Bargaining chip," a concept that comprises part of what is generally understood as bargaining power, has always been an inherent feature of negotiating contexts. It is only recently, however, that this concept has acquired the dignity of being singled out as a distinctive "approach" to arms control negotiations.

Critics of the bargaining chip approach to SALT offer arguments against it that in many cases are poorly articulated attitudes that hide their basic unwillingness to face political reality. Ostensible grievances may be the dollars required for Trident and the B-1, but the real underlying cause may be the belief that men of goodwill should seek to reason together to solve their common problems--problems that are seen as such forces as the Military-Industrial Complex, Technology, etc. Some of these people (the Dedicated Disarmers) favor unilateral self-restraint in American weapon development, believing that the Soviet Union's strategic posture is driven by fear. This school of thought naturally sees only negative values in the concept of arms control negotiations.

An important reason why the bargaining chip rationale for acquiring new weapon systems has attracted critical attention is that neither the Nixon nor the Ford Administration has had a clear strategic doctrine to which new weapons would obviously relate. Apparently critical questions such as the following have never been satisfactorily answered by recent American regimes. What are the principal foreseeable strategic problems of the United States? Lacking answers, it has seemed to many that the bargaining chip rationale has been introduced as a desperation measure to rescue analytically dubious systems that were in serious trouble.

There is good reason to believe that the critics of the bargaining chip rationale are seriously in error on at least two points that are prominent in their arguments. First, analysis suggests that the weapon development and procurement cycles of the superpowers have been substantially independent of each other. Second, no convincing evidence exists that either side has initiated a program <u>because</u> of its putative arms control diplomatic worth alone. The United States may have led the way along many technological paths, but there is scant evidence to suggest that a greater measure of arms race self-restraint would have evoked a sympathetic response in the Soviet Union.

The major problems in relation to which U.S. bargaining chips acquire their market value are the following: the vulnerability of the land-based missile and bomber forces; the maintenance of an essential equivalence of counterforce capability; and political perceptions of the state of and likely future movement in the central strategic balance. One should pursue to the point of deployment only those systems which one believes will work within acceptable limits of performance. One should pursue only through development and testing those systems that contribute significantly to the maintenance or useful enhancement of strongly desired capabilities. Finally, one should analyze very carefully indeed exactly what the relationships are between the systems in question and the guiding doctrine.

BARGAINING CHIP--A PROPER RATIONALE FOR DEFENSE R&D

A. The Bargaining Chip--An Elusive Quarry?

The "bargaining chip" has now attained the heady status of being identified as an allegedly distinctive "approach" to arms control negotiations. Conceptual clarity tends to be the first victim in a bitterly waged debate. While granting that the critics of the bargaining chip approach have indeed scored some points, it is necessary to recognize that bargaining chip, a concept that comprises a portion of what is generally understood as bargaining power, is an ineradicable feature of all negotiating contexts (in the family, in industrial disputes, between agencies of government, and certainly between states). In negotiations, tacit and formal in character, the parties cooperate in managing a stylized and disciplined conflict process at the same time that they struggle to effect an agreement most satisfactory to themselves, unilaterally. The very fact that arms control negotiations are occurring or are in prospect implies a level of political conflict such that the weapons balance between the parties is of some considerable political significance. In short, one may deplore the fact that states contend for advantage in SALT, but only states which are suspicious of each other's intentions, and which read the perceived strategic weapons decisions of each other as an index of intention, need to participate in a SALT exercise at all.

Fundamentally, a bargaining chip is a trading item--but not necessarily an item that one is prepared to trade. The terms of trade are a function of the interaction of (probably) competing and uncertain estimates of the costs and gains to each side of trading--or of not trading. Also, a vital part of a process of negotiation is mutual agreement as to what are and what are not bargaining chips (i.e. there are chips, and

there are bargaining chips). In SALT, for example, the superpowers have contended not merely to place certain chips in the negotiating arena, but also to exclude other potential chips. For example, the so-called Forward Based Systems (FBS) of the United States in and around Europe are "sleeping participants" in the central weapons balance, of obvious and unresolved serious concern to the Soviet Union. But the FBS are to be viewed as bargaining chips as much in the context of West-West as of East-West negotiations.[1] For clarity of discussion, a weapon system may be a bargaining chip in any of the following senses:[2]

- One is prepared to trade it in return for restraint abroad that is judged to be strategically equivalent. However, in the absence of an agreement not to deploy or not to eliminate, one is determined to proceed with the system.
- One is prepared to accept some measure of constraint upon its deployment, but it is believed to be of such strategic, and hence political, potency that its total elimination from the arsenal is nonnegotiable. Such a system may be termed a "reserved bargaining chip."
- One is prepared to trade it in return for restraint abroad that can be retailed to the relevant attentive publics as constituting a fair exchange. But, in the absence of agreement one either has no intention of--or insufficient political "clout" to--complete the development program or retain it in the arsenal. Such a system may be termed, in one perspective, a "counterfeit bargaining chip." In another perspective, namely that of the negotiating-adversary, the system in question may look so threatening that even his comprehension of the unlikelihood of your taking the system "to the wire" (in the memorable Watergate phrase) cannot fully compensate for the perceived risks of a no-agreement context.

---

1 See forthcoming Adelphi Paper (London: International Institute for Strategic Studies, 1975) by Uwe Nehrlich on European perceptions of FBS problems.

2 For an alternative listing, see "A Statement by the Research and Policy Committee of the Committee for Economic Development," Congressional Decision Making for National Security, pp. 34-35 (New York: Committee for Economic Development, September 1974).

B. The Bargaining Chip as Villain

An important point that many bargaining chip dissenters miss is that the world does not encompass only one set of strategic desiderata. Chips that appear worthless, or of only semiprecious metal to an Assured Destroyer (even to a flexible Assured Destroyer),[1] will look very different to a Soviet defense community that sees deterrence and war-fighting as succeeding and fully compatible stages of crisis-war.[2] To the limited extent to which leading members of the American arms control community would now endorse the protracted SALT exercise--to that extent they must allow that the strategic beliefs and political judgments of the Soviet Union determine the exchange value of the United States' bargaining chips.

Although the bargaining chip approach to SALT has been arraigned in relation to such specific systems and strategies as the Safeguard ABM, Trident, the B-1, the long-range cruise missile programs, the MX ICBM concept and even Dr. Schlesinger's well-publicized retargeting exercise, such complaints often reflect, in reality, poorly articulated fundamental attitudes towards arms control negotiations and towards the utility of strategic forces.[3] From the same analytical stable that brought forth mechanistic action-reaction theorems in the 1960s has emerged the logical corollary that the United States should purchase only those strategic systems which it needs in order to fulfill its essential strategic tasks. At first glance this is an unexceptionable criterion of sufficiency. However, many people in the United States and elsewhere believe that the strategic

---

1 Proponents of an assured destruction doctrine have, of very recent times, been eager (however belatedly) to deploy their flexibility credentials. See Albert Wohlstetter, "Threats and Promises of Peace: Europe and America in the New Era," Orbis, Vol. XVII, No. 4, pp. 1134-1137 (Winter 1974).

2 John Erickson, "Soviet Military Policy: Priorities and Perspectives," The Round Table, No. 256, p. 370 (October 1974).

3 Illustrative of the critical literature is George W. Rathjens, Abram Chayes, and Jack P. Ruina, Nuclear Arms Control Agreements: Process and Impact particularly pp. 18-21 (Washington, D.C.: Carnegie Endowment for International Peace, 1974).

arms race--and indeed, necessarily, SALT--is a political exercise. Political appearances may well be the very stuff of more or less confident foreign policies or, to rephrase, of a more or less robust deterrent.

Underlying some of the criticism of the bargaining chip rationale for new weapon systems is an unwillingness to accept political reality. The arms race is felt to be so expensive, so dangerous and so affronting to the decent opinion of mankind, that it is deemed quite inappropriate for the United States to seek to negotiate from (more) strength and to jostle for advantage in SALT. The *lingua franca* of the dissenting voices may be the dollars for Trident and the B-1, but the structuring belief is that men of goodwill, from East and West, should seek to reason together in order to solve their common problems. The common problems in this context being our human status as "targets all," while the real adversaries are such sinister forces as Technology, the Military-Industrial-Complex (and its presumed Soviet equivalent), conflict ideologies and "the National Security Managers" that feed upon them.

Dedicated Disarmers would reverse the common meaning of the bargaining chip approach. Instead of proffering more and less credible and threatening negative incentives to agree, they would have the United States offer positive sanctions or rewards. Unilateral self-restraint in American weapons development should reduce anxiety in the Soviet Union and hence should weaken the arguments of the Moscow chapter of the hawkish community. Presuming that the Soviet Union's strategic posture is driven by a conservative prudence born of fear--the provision of sufficient evidence of benign American intentions should induce a "sympathetic parallelism" of arms reduction which could (and perhaps should) even obviate the need for formal interstate negotiations. In other words, arms control begins with a pure heart--at home.

The school of thought identified above sees arms control negotiations as being of net negative worth for the classical goals of arms control. Although bargaining chips are a feature of all interstate relations,

inside and apart from formal negotiations, there is no doubt that the prospect of explicit, detailed agreement does yield prominence, salience and focus to bargaining chip arguments. While granting some positive features to SALT, uncompromising disarmers (appearing under the more fashionable rubric of arms controllers) perceive--quite correctly--that SALT has little or nothing to do with controlling armaments or resolving real, as opposed to illusory, strategic problems. It is beyond the scope of this paper, but the inutility of SALTs I, and prospectively II, for the solution of the principal strategic problems of the United States is not entirely attributable to the character of the arms control modality. A good strategic posture, like arms control, is a domestic product.

C. The Bargaining Chip Rationale: Use and Abuse

Doctrinal preference and bargaining chip complaints are inseparable elements of belief-analysis. As a strictly empirical point, it is true that the deployment prospects for some ABM, for Trident and for the B-1, _inter alia_, were and are much improved by the firing of bargaining chip assertions across the bows of sceptical Congressional committees. If one happens to believe that these systems are cost-ineffective and that their arms control diplomatic connection resulted and will result in their being deployed, then clearly the bargaining chip rationale is of negative worth to the national security (money is wasted--needless anxiety--and matching or offsetting systems are purchased abroad). On the other hand, if one believes that the Soviet Union is not seriously interested either in (a) arms reduction, or in (b) qualitative arms restraint, and if--furthermore, and in consequence--one believes that such systems as Safeguard, Trident and the B-1 are of strategic and political value, then clearly their SALT utility, if any, is strictly a useful bonus. Technically sound and strategically valuable systems, facing a barrage of domestic criticism, need all the support that can be mustered. The only dangers in deploying the bargaining chip rationale are that SALT negotiators might actually bargain them away in a poor trade, and that the systems in question might be devalued by association with a (foolishly) discredited argument.

The scope for individual judgment with respect to the worth of a particular weapon system is such that no strictly technical resolution of the uncertainties is possible. Two key questions stand out. What is the negative incentive for the SALT adversary to come to acceptable terms, if the United States deploys, or credibly threatens to deploy, a particular weapon system? (For example, was the Nixon Administration's protracted defense of Safeguard vindicated in SALT I?) What is the value of a particular weapon system? If it is claimed that the U.S. Air Force will acquire the B-1, in good part because of SALT--what is the B-1 worth to the United States? One may calculate the extent of the surface damage that the survivors of a 244-strong force of B-1s should be able to inflict on the Soviet Union under arbitrary, specified conditions. But how will the B-1 contribute to perceptions of the strategic (im)balance? One may argue that most of the B-1s strategic tasks can be performed by other, less costly systems--but how does one compare the political utility of competing weapon systems? Some analysts will trump this question by claiming that the B-1 or its alternatives should ensure a healthy redundancy of the means to deter--and one deters by means of promising massive urban-industrial damage. The political (in)utility of strategic forces is expressed in its totality in that genocidal formula. How can one demonstrate, to the profoundly critical in an era proclaimed as one of detente, that a very expensive and possibly strategically redundant weapon system could just tip the balance of decision in the minds of adventure-contemplating Politburo members in 1984? One may argue that most politicians are strategically innumerate, and that their preference for a quiet as opposed to an exciting international life will be quite unaffected by "pinwheel" calculations--they think in broad politico-strategic terms. But professional strategic and arms control analysts will likely remain unconvinced. It must be added that strategic arithmetic is not at all likely to buttress the belief of stalwart arms controllers that prominent bargaining chip systems (in their identification, at least) should not be deployed, because major counterforce capabilities are unattainable by either side.

Although this paper is not friendly to thoroughgoing critics of the so-called bargaining chip approach to arms control negotiations, their central argument, properly translated, should wholeheartedly be endorsed. To be precise, counterfeit tradeaway chips should not be developed and deployed. If a weapon system has no substantial potential strategic and/or political worth to the United States, save as a makeweight in a strategic force mix that will be constrained by SALT, then that system should never proceed beyond early development. This statement is offered even in the knowledge that a very poor system might nonetheless drive foolish Soviet leaders into weakening their overall strategic posture by deploying excessively expensive countermeasures. The United States' research and development community is capable of devising better systems than those useful solely for budgetary gambits. Contrary to the judgment of many analysts, Soviet acceptance of token ABM deployment in the ABM Treaty most probably reflected neither their acceptance of mutual assured destruction doctrine nor any excessive respect for Safeguard. Much more likely is it that Soviet leaders were impressed with the war-fighting (and hence, in their eyes, the deterrence) worth of follow-on American hard-site ABM deployment.

D. Good Answers First Require Good Questions

One important reason why the bargaining chip rationale for new weapon systems has attracted critical attention is because the Nixon-Ford Administrations manifestly have lacked a clear strategic doctrine to which new weapons would obviously relate. These Administrations have betrayed considerable internal division over strategic desiderata, and--at critical junctures--have given evidence of the belief that SALT agreements could be a functional substitute for a clear strategic rationale. If the United States lacks a clear strategic doctrine that indicates what kind of capabilities are desired (and how strongly they are desired), then it is, as a consequence, difficult to attach any very definite or convincing-sounding rationales to particular systems or chips.

Before one can devise a good arms control regime, one must first enquire as to what one requires of such a regime--by what criteria should it be judged? Such an enquiry presupposes the prior posing of the question--what are the principal foreseeable strategic problems of the United States? One cannot finesse this question by claiming that, for example, SALT I or SALT II is really about the political relations between the superpowers. The strategic details, the deployed and deployable chips are not mere technical trivia. Strategic imbalances, real or hypothetical (but plausible) will be seized upon by domestic political opponents--if they are not first turned to foreign policy use by the primary interstate adversary--and will thereby feed back negatively into the detente process supposedly forwarded by the arms control regime.[1]

Many well-respected members of the arms control community, in alliance with sceptical Congressmen, are extremely unfriendly to those weapon systems and doctrinal adjustments that have come to be identified as bargaining chips. Although bargaining chip expresses a fundamental truth concerning the dynamics of negotiation (i.e. that the final terms of a Treaty or Agreement will reflect (a) your bargaining strength, or chips, and (b) how well you play with your chips in the game), the negative connotations of the term are such that its continued use will harm the defense posture of the United States. The official proponents of bargaining chip rationales were not at fault in so doing, but they were (and remain) at fault in not devising a conceptually robust doctrine that would have restricted sharply the influence of the more generic critics of strategic programs. It must be admitted that the domestic political context was hardly propitious for the thoroughgoing revision of assured destruction and arms control doctrines.[2]

---

[1] For a full statement of this argument, see Colin S. Gray, "SALT and the American Mood " (December 1974) (unpublished).

[2] On the contemporary strategic debate, see Colin S. Gray, "Rethinking Nuclear Strategy," Orbis, Vol. XVII, No. 4, pp. 1145-1160 (Winter 1974); Ted Greenwood and Michael Nacht, "The New Nuclear Debate: Sense or Nonsense?", Foreign Affairs, Vol. 52, No. 4, pp. 761-78 (July 1974); and Laurence Martin, "Changes in American Strategic Doctrine--An Initial Interpretation," Survival, Vol. XVI, No. 4, pp. 158-164 (July-August 1974).

Even to Congressmen and analysts who were not, in principle, hostile to the bargaining chip rationale, it did seem as if the rationale was being introduced as a desperation measure to rescue analytically dubious systems that were in serious trouble. Soviet negotiating reactions to the intermittent bargaining chip debate in the United States must remain a matter of speculation. In this connection the Vladivostok Accord of November 1974 lends itself to contrasting interpretations. On the one hand, one may argue that the Schlesinger doctrine--first announced in barest outline on 10 January 1974, married to the improvements in counterforce capability that the doctrine needs in order to be fully effective,[1] set in a context of apparent American determination to proceed with Trident and the B-1--persuaded the Soviet leaders that protracted deadlock in SALT would spur new and ominous American war-fighting capabilities.[2] On the other hand, one may prefer to argue that while the above reasoning is probably correct, the Vladivostok Accord was endorsed because it was judged that the United States would be more likely to lack the political will to translate its bargaining chips into the building blocks for new capabilities in the context of a SALT II regime, as opposed to a context of no-SALT II regime.[3] In other words, the Schlesinger doctrine and the initial funding of new technologies for improved accuracy and yield-to-weight ratios (inter alia), performed admirably as SALT-directed signals--but anticipated lack of

---

[1] The most substantial statements of the doctrine are James R. Schlesinger, Annual Defense Department Report, FY 1975, pp. 3-6, 25-45 (Washington, D.C.: Government Printing Office, 4 March 1973); and U.S. Congress, Senate Committee on Foreign Relations, Subcommittee on Arms Control, International Law and Organization, U.S.-U.S.S.R. Strategic Policies, Hearing, 93rd Cong., 2nd Sess. (Washington, D.C.: U.S. Government Printing Office, 1974).

[2] Just how effective the new technologies will be that are currently "within the state of the art" is a matter for conjecture. To cite but one, Soviet leaders should be very worried indeed about the fitting of the Advanced Inertial Reference Sphere (AIRS) onto American ballistic missiles.

[3] So many diverse, though linked factors, may serve to accelerate or to retard the pace of competitive arms acquisition and improvement, that it is far from certain that 1985 with SALT will be significantly more stable than would be 1985 without SALT.

alarm in the United States in the wake of SALT II should see the Soviet Union on to the "broad sunlit uplands" of strategic superiority (which, if it seemed plausibly to be about to occur, should catalyze a massive "crash" American arms race reaction).

E. "Chips" for Arms Racing

There is good reason to believe that the critics of the bargaining chip rationale are seriously in error on at least two points that are prominent in their arguments. First, careful arms race analysis suggests that the weapon development and procurement cycles of the superpowers have been substantially independent of each other.[1] Second, there is no convincing evidence to the effect that either side has initiated a program *because* of its putative arms control diplomatic worth alone--*or* nearly alone. (One does not build weapons in order to control them--for a *reductio ad absurdum*.) This is not to deny that systems in political difficulty have not been defended almost exclusively in bargaining chip terms. But this admission does not carry the implication that the defending officials did not believe in the strategic and political value of the systems in question. To link the two points: what we now know concerning arms race dynamics suggests that weapons technology offers "ripening plums"[2] rather than quick diplomatic "fixes" to meet negotiating deadlines. The "plums" stem from the ongoing activities of large research and development communities. Action and reaction in the arms race tends to the macro and time-lagged as opposed to the micro and immediate.[3] Therefore, although Safeguard, MIRV, the B-1, Trident, AIRS and the MX,

---

[1] Erickson, "Soviet Military Policy: Priorities and Perspectives," pp. 369-373, in Andrew W. Marshall, *Bureaucratic Behavior and the Strategic Arms Competition* (Santa Monica, Cal.: The Southern California Arms Control and Foreign Policy Seminar, October 1971).

[2] See Elizabeth Young, *A Farewell to Arms Control?*, p. 195, footnote 51 (London: Penguin, 1972)

[3] Colin S. Gray, *The Soviet-American Arms Race: Interactive Patterns and New Technologies*, WN-8719-ARPA, Chapter 4 (Santa Monica, Cal.: RAND Corporation, August 1974).

to cite but a few, are of necessity American bargaining chips--which is to say that they are counters on the U.S. side of the SALT table--it would be incorrect to assert that these developments have, do and will spark specific Soviet counterdevelopments. In a very real sense, all of the items just mentioned constitute part of a continuing American determination to offset and match varying degrees of Soviet first-strike effectiveness. The United States may have led the way along many technological paths, thereby sensibly infringing the classic rule of arms race practice for the arms race leader of "never be the first to innovate," but there is scant evidence to suggest that a greater measure of arms racing self-restraint would have evoked a sympathetic response in the Soviet Union. On the contrary, the past evidence of arms race practice suggests that a slackening of endeavor by the leader encourages the Power behind to race harder because the task of catching up looks less arduous.

If critics of the bargaining chip approach are taken at face value, and it is assumed that they favor balanced (in terms of capabilities <u>and</u> appearances) arms control agreements, the consequences for the United States of participation in SALT would, in all likelihood, have been even more unhappy than is the case now. Admittedly, some analytical sleight-of-hand is here being effected. Namely, the arguments and proposals of the critics are being considered in the context of an arms control process wherein the negotiating adversary is deemed to be conducting his affairs in a determinedly competitive mode. The strategic weapon systems of the United States (and many of the theater systems) are bargaining chips, they do represent the corpus of one's extant and prospective strategic weight, whether or not one chooses so to regard them. In a negotiating process, how could they be anything other than chips that both sides will take into account? In short, if one enters the SALT (or MFR) forums, it would be a logical (not to say political) absurdity to disclaim the bargaining chip approach. Determined eschewal of the bargaining chip rationale before the Congress would not have resulted in a "bargaining chipless" SALT exercise. It would simply have meant that the United States had fewer chips on its side. If it is granted as a law of

life that bargaining strength and skill determines the outcome of negotiations, then, in this barren scenario, the Soviet Union (which must rank along with North Vietnam and the Chinese People's Republic among the toughest of state bargaining "teams") must have emerged from SALT with many more pluses on its side of the arms ledger than was in fact the case. One can claim that the strategic arsenals of the superpowers are now so vast that these hypothetical pluses would have been of no significance, strategic or political--but such would simply merit the status of being an imprudent assertion that would be contrary to almost everything that we know concerning Soviet politico-strategic thought and practice.

By way of an interim summary, the following constitute the heart of the above argument:

- Neither superpower (to our knowledge) has initiated weapon programs solely with an arms control negotiation bargaining role in mind.
- Neither superpower reacts specifically and predictably to particular weapon developments that are labeled (or labelable) as bargaining chips.
- All weapon systems should be seen as being intended to influence the politico-strategic behavior of potential foes. In this maximally broad conception, all weapons are bargaining chips all of the time. In talking of the bargaining chip approach, one is merely restating a fundamental characteristic of interstate politics.
- Prominent utterances to the effect that "system X or Y is a bargaining chip for SALT" should be unnecessary before a sophisticated attentive public.
- However, to invoke the bargaining chip rationale in aid of systems that are technically very unpromising, is both to downgrade the diplomatic utility of those systems and to devalue the currency of bargaining chip arguments.
- Often, of recent years, the deployment <u>in desperation</u> of the bargaining chip rationale attests not to the strategic absurdity and/or technical doubts that pertain to the system, but rather attests to a particular mood in the attentive public. If a country's elected representatives decline to be moved by powerful strategic and political arguments, one can but

wait for external events to effect a shift in the domestic mood and hope that that shift will occur in time for the lacunae in the defense posture to be filled.

- Weapon developments that should be given high priority are not much assisted by fairly mindless repetitions of naked bargaining chip rationales. Any system that is defensible only in terms of its alleged influence over the Soviet mind should be terminated. Unless one is prepared to invoke stupid or backward Russians, as some American analyst-commentators persist in doing,[1] the "SALT diplomacy only" rationale should fall of its own contradictions. At the very least, since Soviet leaders must be presumed to be impressed only by systems that it would be of value to the United States to deploy, one should enquire closely as to what it is about "system X" that is believed so to impress them. The serious posing of such a question does, of course, carry the implication--which is unpalatable to some--that one might be able to learn from the Soviet Union in matters strategic.

F. Bargaining Chips and Strategic Doctrine

It was noted above that bargaining chip rationales will not, for more than the short run, suffice to man any serious breach in strategic doctrine. Furthermore, it was stated that strong as opposed to weak bargaining chips are prospective systems that clearly one has a very substantial incentive to deploy. While granting the incentives of service organizations, in alliance with industrial suppliers, to purchase the latest and most exotic of systems, and also while granting the necessarily patchwork character of a nation's strategic doctrine--it is the case that new systems cannot, in the 1970s at least, be retailed successfully solely on the rationale that one is modernizing the arsenal. The U.S. Army's experience with its attempts to modernize its stockpile of 8-inch and 155mm nuclear artillery shells stands as a classic warning of how not to sell

---

[1] See John Newhouse, Cold Dawn: The Story of SALT, pp. 3-4 (New York: Holt, Rinehart and Winston, 1973).

new programs.[1] To be sold as chips for the curtailment of the deployment of which a prospective adversary must pay a substantial price, new weapon systems must be demonstrated plausibly to be expected to make a unique and nonmarginal contribution to the solution or alleviation of the strategic problems of the United States. In short, a good bargaining chip can only exist in the context of a strategic posture the future problems of which have systematically been addressed. Only such a continuing enquiry will yield a doctrine sufficiently resilient as to enable one to pursue a "bargaining chip approach" reasonably secure in the knowledge that domestic critics can be overwhelmed and that (partly as a consequence thereof) the negotiating adversary will accept tolerable terms of trade. Such an enquiry should be conducted in voluntaristic as well as in necessity terms (i.e. not merely, "what problem will the outside world pose for us," but also "given an outside world of a certain broad politico-strategic character, what capabilities would we like to acquire and sustain?"). To illustrate, looking at SALT I and at the Vladivostok Accord, it is far from certain that the U.S. Government has "autonegotiated" within itself to the point where there is agreement as to what the major future strategic problems of the United States are likely to be.

In summary form, the major problems (in relation to the alleviation of which U.S. bargaining chips acquire their market value) would seem to be the following:

(1) The vulnerability of the land-based missile and bomber forces.

(2) The maintenance of an "essential equivalence" of counterforce capability.

---

[1] Note the discussion in U.S. Congress, Joint Committee on Atomic Energy, Subcommittee on Military Applications, Military Applications of Nuclear Technology, Hearing, Part 1, pp. 10-15, 43, 46, 93rd Cong., 1st Sess (Washington, D.C.: Government Printing Office, 1973).

(3) Political perceptions of the state and likely future movement in the central strategic balance--conceived of as an undifferentiated whole.

The MX heavy (approximately 10,000 lbs of throw-weight) ICBM concept could help considerably with (2) and (3), but it can do nothing for (1) unless one either adopts a launch-on-warning tactic or deploys a dedicated hard-site ABM defense--neither of which is at all likely over the next decade. The B-1 should be very helpful for (1), but it is a probable fact that very many observers of the arms race have long been conditioned into believing that long-range manned bombers are somehow old-fashioned. Despite the fact that bombers have a theoretical political demonstration value not shared with ballistic missiles (i.e. they can be moved from base to base, they can appear on radar screens--and yet not be committed irrevocably--they are an easily monitored index of one's state of political alarm), it is very probable that the United States will not obtain the political benefits from their continued large-scale--and modernized--deployment that careful analysis suggests should be the case. Moreover, without denying the probability that most of the bombers that reach their safe-escape points would successfully complete their missions (estimates vary, but the sensible range would seem to be between 60% and 80%), it remains a very prominent fact that the bomber force--alone among the legs of the Triad--would have to contend with a vast and alerted active defense system.

Technical strategic analysis of future possible vulnerabilities is very important, just in case an adversary is tempted to try for a nuclear "ambush at the pass." But the analytically softer problems of maintaining counterforce equivalence and a parity of political esteem (self and other regarded) are scarcely less important as rationales for weapon programs that are of necessity, as observed above, to be seen as bargaining chips, and which may have an onerous explicit and expediential bargaining chip aura cast about them. These judgments are matters of personal strategic preference, but--translated into different systems and doctrines for different points of strategic view--they have a very general

applicability. One should pursue to the point of deployment only those systems which one believes will work within acceptable limits of performance, one should only pursue through development and testing those systems that contribute significantly to the maintenance or useful enhancement of strongly desired capabilities, and one should analyze very carefully indeed exactly what the relationships are between the systems in question and the guiding doctrine.[1] In a climate of pervasive scepticism over the rationales offered in support of new weapon systems, the armed services must expect softness in their analyses to be uncovered and exploited. Prospectively very effective bargaining chips may die in a Congressional committee as a consequence of a lack of conceptual clarity and depth on the part of the proponents.

If one elects to resist the notion that all weapon systems are at all times, though in different dimensions, bargaining chips (a correlate of the idea that tacit arms control processes may and do proceed in the absence of an interstate negotiating forum)--then one may reasonably enquire as to the point at which weapon systems do and/or should come to be regarded as chips. The development or deployment of particular forces and systems for the explicit purpose of forwarding one's political influence is as proper and sensible an intention as it is difficult to subject to any form of reality-testing. History happens but once. Hence one cannot prove after the event that things would have been different if "system X" had not been deployed. If one examines SALT I and the Vladivostok Accord and then seeks to isolate, with high confidence, the bargaining "clout" yielded by the Safeguard ABM, by the B-1 and Trident developments, and by the Schlesinger retargeting policy (and ambiguously associated, initially low-cost, technical measures for the improvement of system performance), one is attempting the impossible. Single system

[1] The relationships between strategic ideas and new technologies are not well understood. It is the judgment of this author that most strategists incline to the belief that technology influences doctrine rather more than the reverse is the case. Such a belief needs to be very well qualified, if subtle and obscure feedback processes are not to be ignored.

or capability motivation ("stop the Safeguard-hard-site ABM programs," or "inhibit programs that must provide for lower CEPs") may be attributable to some "tunnel-visioned" strategic analysts, but not to members of the Soviet Politburo. If, as does not appear to be very plausible, "chips" are displayed and employed solely in the context of interstate arms control negotiations, then one cannot arbitrarily designate some prospective weapon systems as bargaining chips and others as partially or totally "reserved," non-negotiable systems. Whether or not a particular system is declared to be a fit subject for arms control deliberations, all systems--deployed, being developed, and at subdevelopment stages--must figure in the bargaining calculations of each side. Perceiving an American weapon development process that is constantly harried by powerful domestic critics, Soviet leaders cannot but discount heavily the strategic (and hence diplomatic) weight pertaining to individual items that, however technically efficacious prospectively, have yet to be translated into men, machines and organizations in the operational inventory.

G. Technologies "on the Shelf"

The last point above is in fairly direct opposition to what may be termed the "minimalist bargaining chip approach." According to the advocates of this approach, bargaining chip requirements may be met largely in the form of technologies "on the shelf." With some justification, it is believed that the Soviet Union is impressed not so much by weapons deployed but rather by the enormous scale and variety of the American economic-technological base. Given a very large economy, the proper bargaining chip strategy should involve not the pursuit of particular technologies for very particular weapon systems, but rather the maintenance of a very broad research and development base. From this base the U.S. Government could select the particular mix of complementary technologies required to meet a threat of a unique character. Proponents of varieties of this theme of argument would hold that the dedicated pursuit of a conventional bargaining chip approach cannot help but result in one being "locked into" particular weapon paths which rapidly acquire their

distinctive constituencies as more and more is expended--and is at stake--and as protective self-serving doctrinal rationales are forged. Moreover, one is "locked in" prematurely, in that development and deployment leadtimes are so long, and there is such uncertainty about the future detail of the threat--that one will be countering the adversary's posture as it was in the past. In aphoristic form, if weapon systems are not "killed" very early, they are unlikely to be killed at all--abortion is preferable to murder or to euthanasia.

Unfortunately, from the point of view of economy and indeed of arms control, the above line of argument tends to confuse a general and somewhat platitudinous truth with a strategy for research development and deployment. It is undeniably the case that the later the stage of development of a weapon, (a) the more costly are any desired technical changes, (b) the fewer are the technical changes that are possible--given the technical defining parameters of the system, and (c) the stronger will be the constituency of those interested in seeing the system through to deployment--warts and all. However, no adversary is likely to grant one from five to ten years' notice of an intention to wage an intense crisis or to go to war (to slip into archaic phraseology). Crises and wars--though not necessarily arms races--cannot be waged successfully with blueprints, "mock-up model" and a few prototype test vehicles. The external threat is always dynamic in nature: hence one will always be able to devise a more appropriate strategic posture tomorrow than one can today. Reasonable complaint against the "technology on the shelf" approach to bargaining chips may take two principal forms. First, one would be purchasing a better posture for the long term (which never comes), at the cost of a better posture for the short and medium terms. Second, as all primers on deterrence theory endeavor to inculcate in their readers, deterrent effect is a function both of capability <u>and</u> of will. A country manifestly unwilling to commit itself to major expenditure upon strategic weapon systems--whatever the sophisticated rationales--would look very much like a country which was easing out of a serious arms competitive enterprise. If one presumes a cooperative Soviet Union, reacting in sympathetic parallel to

this perception, then this bargaining chip strategy would serve the cause of arms control better than have all the meetings convened since the contemporary superpower arms control dialogue began in earnest in 1958 (with the Geneva "Surprise Attack" Conference). Alas, there are no grounds of any substance for presuming that such an exercise in parallel self-restraint constitutes a likely sequence of events (and nonevents).

Those who believe that the bargaining chip of the United States is really its economic-technological base, expressed in terms of a wide variety of weapons options that could be operationalized in short order, seem really to be rationalizing their aversion to large-scale defense expenditures and to presumed "provocative" arms racing activity. Crucial to the "research and development options as bargaining chips" theme, is the assumption that one could in fact put high-technology programs (or potential programs) into a protracted "holding pattern" against strategic need. There is every reason to believe that this assumption is false. Weapon systems cannot be developed as perfected master-copies that can be run through a military-industrial xerox machine for near-instant reproduction in time of strategic demand. Research and development teams are maintained by a collective commitment to see their projects through. Comparatively few engineers could be motivated to work upon projects that they knew would most likely only sit on the shelf (sexual intercourse without a climax). At some risk of stating the obvious, an acute international crisis can develop in a matter of hours--how long does it take to produce even a "readied" weapon system in large numbers, and then to "shake it down" for reasonably assured operational utility?

These assorted complaints may seem excessive, but they are necessary in order to discredit a strategy of procrastination that masquerades as a sophisticated and economical bargaining chip approach to the management of an interstate strategic relationship. Capability and will are not synonymous. The substantial community of professional Washington-watchers in Moscow must be presumed to be capable of distinguishing between an index of interest (large sums of money devoted to the solution of a strategic

problem) and a signal of future determination (contingent promises to deploy strategic capabilities X, Y and Z).[1] Americans may believe their contingent threats as they utter them, but who can say what the politico-strategic convictions and the associated moods of the American people will be in 5 to 10 years' time? In principle, the diplomatic utility of weapon systems that are still at an early stage of development is fully compatible with a bargaining chip approach that is addressed to the long-term problems of strategic stability. But, in practice, unwarranted delay and indecisiveness may be the product of this approach. It is necessary to return to an admonition uttered above. Namely, a credible bargaining chip approach can only rest upon an unmistakable determination to solve perceived strategic problems. Developed technologies that are widely known to be "on the shelf" can be expected to influence Soviet minds only if "on the shelf" status is not taken as an index of a reluctance to race vigorously.

Both weapons deployed and weapons (almost certain) to be deployed are bargaining chips--whether or not one so proclaims them--but the exchange value of weapons in place is higher than is that of weapons which will probably be deployed in large numbers only after a minimum delay of several years. Appreciation of bargaining chips, in the form of technologies yet to be deployed, will certainly influence the competitive-cooperative management of the central strategic balance, but they are not components of that balance. One might just "win," or not lose, an arms control exercise on the basis of adversary appraisal of the strategic posture that one could deploy as of the early 1980s--were one unconstrained by an arms control regime. But, if crisis and war occur in the near future, the capabilities of the 1980s can be of no value (first one must survive the 1970s).

---

1 On the crucial distinction between signals and indices, consult Robert Jervis, The Logic of Images in International Relations, particularly Chapter 2 (Princeton, N.J.: Princeton University Press, 1970).

H. Conclusions

An exploration of the character, meaning and utility of bargaining chips in the context of interstate arms control negotiations is a venture into terra incognita. Despite the ubiquity and long history of bargaining behavior and despite the conceptual prominence accorded bargaining in the strategic theory of the period 1955-65, the arms control history and the arms control debate of the five years of SALT demonstrate that very little indeed is understood of bargaining chip phenomena. Although this paper is addressed specifically to the complex of bargaining chip problems, it should be noted that uncertainties in this area are a faithful reflection of a much wider ignorance. Political scientists and practitioners have not addressed themselves to the question of "how does one go about securing good (a significant improvement for both parties upon their expectations of their future in the absence of agreement) arms control agreements?" A related question is "what determines the specific outcomes of an arms control negotiating exercise?" The obvious answer must be "relative bargaining power." However, political scientists have--in Herman Kahn's felicitous phrase--a trained incapacity to cope analytically with the concept of "bargaining power";[1] while practitioners tend to view the mechanics of negotiation as a form of tribal folklore which can be learnt only through experience (to do is to know, aided and abetted by the aphoristic wisdom of the diplomatic Tribal Elders).

To the uncertain extent to which particular American bargaining chips helped shape the terms of a SALT I and a Vladivostok Accord responsive to American strategic needs (to the limited extent to which they were thus responsive), this shaping process would seem to have been at least as much the product of accident as of design. The SALT context has

---

[1] See I. William Zartman, "The Political Analysis of Negotiation: How Who Gets What and When," World Politics, Vol. XXVI, No. 3, pp. 385-399 (April 1974).

encouraged the unscrupulous deployment of ill-considered bargaining chip arguments by officials before Congressional committees; while, in the negotiations themselves, a hesitant and confused endeavor to secure negotiating advantage from hypothetical American strategic postural futures met with little very obvious success. The bargaining chip approach is inherent in the very nature of a negotiating process. The only choices open to the United States are, first, whether it will bargain effectively or otherwise with its chips, and second, whether it will have more or fewer chips with which to bargain.

NET TECHNICAL ASSESSMENT METHODOLOGY - ITS VALUE IN

RESEARCH AND DEVELOPMENT PLANNING

by

J. Jacobs

NTA METHODOLOGY--ITS VALUE IN R&D PLANNING

SUMMARY

A net assessment is an analytical judgment of the consequences of an interaction of organized groups in competition or conflict in a defined environment. A net technical assessment (NTA) deals with the technical parameters and performance of elements engaged in the interaction and is therefore particularly appropriate where hardware, such as weapons systems, plays an essential role in the contest.

There are two overlapping systems of classifying defense-oriented NTA. One system has four categories: technology comparisons, like weapon comparisons, opposing weapon engagements, and opposing force unit engagements. The other system considers NTA assessments from the point of view of side-by-side, face-to-face, and sword-on-shield comparisons.

- Technology comparisons attempt to determine the relative status of the knowledge and skills of the two adversaries in one or more fields of technology. The results of such assessments are usually expressed in terms of time lead or time lag.
- Like weapons comparisons evaluate adversary weapons systems designed for the same mission. The weapons are compared by simulating each in the performance of a set scenario. The assessments provide the effectiveness numbers and, more importantly, which principal technical characteristics enhance the system's effectiveness and which limit it.
- Opposing weapon engagements consist of the analysis of one-on-one offensive weapons versus defense weapons, for example, the tank versus the antitank missile. The assessment presents the principal technical characteristics of the weapons on each side and identifies those that are decisive in determining the outcome of the duel.
- Opposing force unit engagements analyzes offense versus defense at the tactical unit level.

The primary application of NTAs is, of course, to support net assessments. Significant contributions have been made to SALT and MBFR negotiations by this technique. NTA is also useful in determining the most effective R&D programs because of its emphasis on technical performance requirements and deficiencies.

Sword-on-shield NTA, because of its use of an independent threat definition and because of its ability to identify which technical features should be emphasized to enhance mission effectiveness, provides the most realistic method of establishing a priori definitions of development goals and technical parameter trade-offs, should cost or schedule constraints limit the choice. Sword-on-shield NTA also provides guidance in determining correct "blend" of technical performance characteristics and provides a performance criterion both for the design of test and evaluation experiments and for rational decisionmaking when the number of viable options must be limited. Side-by-side NTA is useful in directing the program thrust in the research and exploratory development categories. It is in the effective implementation of this principle that NTA can make its greatest contribution to R&D planning.

Although the use of NTA has been considered expensive, the alternative is to make far-reaching decisions on the basis of judgment or opinion alone. The use of NTA contributes to judgment and in the process builds an analytical base which will enable shorter response time, with consequent cost reduction. When time constraints do force a resort to judgment, use of the analytical base should produce more effective decisions.

NET TECHNICAL ASSESSMENT METHODOLOGY - ITS VALUE IN RESEARCH AND DEVELOPMENT PLANNING

A. Introduction

This paper, one of a set of Defense Research and Development issue papers, addresses the use and value of Net Technical Assessment (NTA) in the R&D process. It will attempt to explain NTA and differentiate it from other analytical techniques. The conceptual relationship to the R&D planning process is described. The key issues with respect to this application are defined. The value (both present and potential) and the limitations of NTA are discussed. The purpose of recording these ideas is to assess the ability of NTA to improve the efficiency and effectiveness of Defense R&D in which process, it is asserted, NTA has a valuable role.

In section B, NTA is defined and the types of assessments are described. The comparison and differences of NTA to systems analysis and cost-benefit analysis are described and the objectives and uses of NTA are listed.

Section C focuses the issues to be discussed by formulating specific questions. These are addressed in section D.

Section E summarizes the answers found.

The paper and its contents are the sole responsibility of the author but I have been greatly aided in organizing these thoughts by informal discussions on this topic with a number of people concerned with the production, direction, and application of net technical assessments. Because I have not offered these people the opportunity to review these remarks, I will refrain from direct attribution. Specifically I would like to

acknowledge the contributions of: Paul Berenson, Joe Douglas, Terrill Greene, Don Harris, Maurice Lipton, Andrew Marshall, Joseph Navarro, Wayne Peale, Robert Turner, and Charles Wilcox.

B. Background

1. Definition of NTA

NTA is a subset of Net Assessment so we will first define that term. A net assessment is an analytic judgment of the consequences of an interaction of organized groups in competition or conflict in a defined environment. The groups may be political, social, or business. The competition/conflict is for status that neither side can totally achieve. The defined environment is the set of initial conditions, measured, estimated, or assumed, of the exogenous factors affecting the interaction (and possibly affected by the interaction). The interaction is initiated by a specified act by one of the parties and proceeds by mutual responses among them in the sequel. The analysis of the interaction will involve (in general) political, economic, organizational, and technical factors. A net assessment, then, produces an analytically reasoned response (rather than an opinion) to the question, "What will be the consequences if we take action X?" Obviously, an analytically reasoned response is only possible where the behavior of the opposing elements is representable by behavioral or performance models. Of crucial importance to the process is the need for independence in the data sources for the opposing element model parameters. Thus for international interactions, the parameters needed for the foreign systems models should be estimated by the intelligence community and the U.S. component behavioral parameters by the responsible U.S. governmental agency. This must be done without a-priori bias or limit setting other than the time period and environmental condition in which the interaction initiates. The situation analyzed could be multilateral, but we will restrict ourselves to bilateral situations in the sequel.

NTA is the technical component of net assessment although the term has been broadened to include activities which properly are precursors to NTA in support of net assessment as defined above. NTA deals with the technical parameters and performance of elements engaged in the interaction and therefore is particularly appropriate where hardware, such as weapon systems, is salient in the contest. NTA exposes the technical factors (strengths and weaknesses) which control the outcome.

While this discussion is oriented toward NTA as a process and a product, the term is also used as an organizational entity which commissions such studies.

2. Types of NTA

There are two overlapping taxonomies of classification of defense oriented NTA by type of "engagement." One classification has four types: Technology Comparisons, Like Weapon Comparisons, Opposing Weapon Engagements, and Opposing Force Unit Engagements. The second classification considers only three types: Side-by-Side, Face-to-Face, and Sword-on-Shield.

Technology Comparisons attempt to determine the relative status of technical knowledge and skills of the two adversaries in one or more fields of the technology. Since technological status is generally a monotonically increasing function of time, the results of such assessments generally are stated as time lead or timelag. Another result of value for comparisons over manifold technologies (multidimensional in technology space) is the divergence of technology advance (difference of the technology growth gradient vectors). In the second scheme of classification, this type of analysis is Side-by-Side.

Like Weapon Comparisons evaluate adversary weapon systems designed for the same mission. The weapons are compared by simulating each in the performance of a set scenario. The outputs are the effectiveness numbers and, more importantly, the principal technical characteristics which enhance and which limit the systems effectiveness. This

type of NTA also would be classed as Side-by-Side except where the weapon systems are designed, and the comparison scenario directs, combat roles against each other; e.g., fighter aircraft vs. fighter aircraft or tank vs. tank. In this case, the NTA would be called Face-to-Face in the second classification scheme.

Side-by-Side Comparisons are not NTAs in the strict sense of the definition above. This is because there is no interactive situation (unless one wishes to contrive a contest such as an air race). However, they are considered as NTAs by usage and they serve a role in the process which will be described in the succeeding sections.

Opposing Weapon Engagements entail the analysis of one-on-one offense weapons versus defense weapons; e.g., tank vs. antitank missile. A single weapon may be tested against several possible opponent systems but only one at a time. The output again is the principal technical characteristics of the weapons on each side which determine the outcome of the duel. In the second taxonomy, these assessments are called Sword-on-Shield.

The fourth type of NTA, Opposing Force Unit Engagements, is offense versus defense at the tactical unit level. The units may comprise single weapon systems or a mix which would be used in concert in the mission represented. Output as always identifies technical strengths and weaknesses which drive the mission result. This assessment also would be labeled Sword-on-Shield in the second scheme of classification.

Realism, complexity, uncertainty, and input data needs increase for performance of various NTA types as ordered above. These categories, while useful in explaining the breadth and scope of NTA activity, should not be considered rigid or restrictive. The spectrum of activity is more or less continuous and the typing is a convenience for partitioning.

3. Comparisons With Other Kinds of Analysis

NTA is a type of technical analysis. As with any technical analysis input data are collected and structured; these data are processed by applying behavioral and physical knowledge and results are produced. So questions arise such as, "How does NTA differ from Systems Analysis?" The differences lie in the "rules of the game" for input data and in the outputs sought. The techniques used for processing are essentially the same. The rules require the behavioral characteristics of the opposing elements to be derived from independent sources, and the outputs sought are why the outcome (technical strengths and weaknesses) more than what is the outcome. NTA differs from cost-benefit analysis in that (a) NTA does not explicitly consider costs and (b) it seeks to answer (in part) "What happens if - -?" rather than "Which is the better investment?" NTA differs from war gaming in that it attempts to examine responses of the elements in a defined stress situation (scenario) in accordance with the design of the elements rather than to determine an outcome expectation by application of statistics and average characteristics. Other comparisons can be drawn, but in summary NTA has a different and somewhat unique point-of-view.

4. Applications of NTA

The primary application of NTA in DOD is, as has been stated, to support net assessment. Significant contributions have been made to SALT and MBFR negotiations by this technique. However, NTA has another charter of comparable emphasis which is to assist DDR&E in determining the most effective R&D programs. This is a feasible use of NTA because of the technology emphasis of R&D and the attention that NTA focuses on technical performance requirements and deficiencies.

With respect to DDR&E R&D planning, here are some potential contributions from NTA:

- Identification of technology gaps and technology trends (in particular, asymmetries) which indicate areas to be explored to avert potential technological surprise.
- Discovery of design rationale/criteria differences which reveal clever ideas overlooked (possibly using on-the-shelf U.S. capability) or potentially revolutionary system possibilities.
- Identification of U.S. system deficiencies which can be remedied by R&D and key technical characteristics for modified design criteria (tradeoffs) which when implemented will enhance effectiveness imbalances in our favor.
- Enhanced effectiveness of available intelligence data by sharpening the specification of the data needs.
- Definition of the impact of broader agreements (e.g. SAL, MBFR) on embryonic systems (current R&D).
- Formulation of R&D policy and strategy and the provision of guidelines for resource allocation.

Other (non-R&D) benefits and applications of DDR&E NTA which should be mentioned are:

- Tactical/doctrinal strengths and weaknesses revealed provide directions to the Services tactics development and training activities.
- Identification of intelligence needs not covered provides assistance to improved intelligence resource allocation.
- Development of the discipline (and some of the results) have other applications; e.g., the Technology Assessment Function of Congress.
- The NTA reports are useful aids to new high-level management appointees who need to be quickly briefed on problems and issues.

C. Statement of the Problem

The DOD has issued a "Statement of Principles for Department of Defense Research and Development." It is reproduced here as Table 3.1 for

TABLE 3.1

DEPARTMENT OF DEFENSE

Washington, D.C.

14 June 1974

STATEMENT OF PRINCIPLES
for
DEPARTMENT OF DEFENSE RESEARCH AND DEVELOPMENT

ROI CONSCIOUSNESS. We must develop and use a deeper and more explicit consciousness of Return on Investment in management of Defense Research and Development.

This return lies in demonstrated deployable capabilities that can be acquired and owned at minimum and affordable cost, and which can be sufficient in performance and numbers to accomplish necessary military and deterrence missions.

TECHNOLOGY BASE. Our greatest long-range asset is our Technology Base. It must be nurtured and managed so that it:

- o gives us great leverage in terms of Return on Investment;
- o constitutes a fully integrated DoD tri-Service activity;
- o searches out substantial increases in military capability and consciously uses technology to reduce costs.

PROGRAM PLANNING. The success of a program is often established or destroyed in its initial stage -- by its concept, its RFP, the program plan and its funding. We must give this part of the process more explicit attention.

VIABLE OPTIONS. It is essential to create viable options which will allow timely low risk development of new systems when the need arises. This can be accomplished by:

- o Forcing, as appropriate, the development and consideration of alternative paths to the same goal;
- o Developing and testing "brass board" or experimental configurations, prototypes, advanced development models and advanced components in response to anticipated need but well in advance of the establishment of firm operational requirements.

COMPETITION. Controlled competition wherever possible--between technical approaches and developers--is a powerful management tool for maximizing Return on Investment.

SELECTIVITY. We must be vigorously selective among competing solutions. In selecting programs, we must insure that:

- o Technical feasibility is used as a necessary but far from sufficient criterion for proceeding with a program.
- o Program progress is geared to demonstrated performance milestones rather than arbitrary schedules or contract constraints. We will support a strong Test and Evaluation program, at the component as well as systems level, to insure performance demonstration throughout development.
- o Unnecessary duplication of equipment designed for similar purposes is eliminated.
- o Inter-Service developments are used to reduce development, procurement, logistics and support costs.
- o Greater emphasis is placed on product improvement as a potentially effective alternative to a new development.

PROGRAM MANAGEMENT. Improved program management is central to our futu and should be recognized and rewarded. We will encourage the building of strong career-oriented technical/business management cadres and will deleg wherever feasible.

ASSESSMENT OF NEEDS. Defense R&D goals should be determined by a combina tion of the potential contribution of the available new technology to specif military needs and the best possible caculated long-term costs.

DESIGN-TO-COST. Design-to-Cost must be evolved as a fundamental and flexible approach to our programs -- it can be a central management tool and communication channel between DoD and industry.

INDEPENDENT RESEARCH AND DEVELOPMENT. A strongly supported IR&D Program is essential. It must be well directed, mostly by industry, and the benefits must be clearly visible.

Malcolm R Currie
Director Defense Research & Engineering

W Parker
Principal Deputy Director
Defense Research & Engineering

Norman R. Augustine
Assistant Secretary of the Army
(Research & Development)

Assistant Secretary of the Navy
(Research & Development)

Assistant Secretary of the Air Force
(Research & Development)

reference. This statement provides guidelines to DDR&E managers for the planning (and direction) of the R&D program. How does NTA contribute to the better fulfillment of these principles? Is it a primary or secondary tool in the implementation or not at all applicable? How well does NTA perform for these tasks where it is a primary tool? Where shortcomings exist how can NTA be improved?

If I assume the "Principles" are complete and that the questions of NTA relevance and contribution can be answered for each, some estimate of value can be derived. With the same assumption, identification of shortcomings and suggestions for modification can be beneficial in enhancing such value. This is what I will attempt to do.

D. Discussion

Let me first consider how NTA might be (or should be) used in the implementation of each of the "Principles." Then I'll comment in general on the use of NTA for R&D planning.

1. Contribution Toward Realization of "Principles"

ROI CONSCIOUSNESS: In conventional ROI analysis a comparison is made of the expected benefit (return) measured in scalar units, e.g. dollars, with investment measured similarly. Time differences and resource flows (rather than lump sum settlements) are handled by discounting. ROI at the simplest level provides an indication of whether to invest or not and, at more sophisticated levels, how to compose an investment portfolio from available opportunities. But how can this be applied to something like an R&D portfolio which has non-scalar benefits with ill-defined time dependence? The principle suggests how the return is to be measured.

"This return lies in demonstrated deployable capabilities that can be acquired and owned at minimum and affordable cost, and which can be sufficient in performance and numbers to accomplish necessary military and deterrence missions."

Sword-on-Shield NTA, because of its use of an independent threat definition and because of its identification of which technical features should be emphasized to enhance the mission effectiveness, provides the most realistic method of a-priori definition of the development goals and of technical parameter trade-offs, should cost or schedule constraints limit the choice. Thus NTA would seem the best way to do a key part of the job and should be considered a primary tool. The cost analysis, however, both resource investment and opportunity costs, is outside the scope of NTA as herein defined.

Side-by-Side NTA has a contribution to improved ROI also. In his statement on the FY 1973 Defense RDT&E Program to the House Armed Services Committee, Dr. John S. Foster, Jr.[1] summarized the results of a Side-by-Side NTA comparing U.S. and Soviet operational weapon systems. This study showed the Soviets ahead in 11 mission areas or weapon types. Some of the features of these weapons which yield superiority (the NTA will identify these) might be copied rather than developed independently with a consequent reduction in development costs.

<u>TECHNOLOGY BASE</u>: Principle 2 directs the nurturing and management of technology so as to "search out substantial increases in military capability." NTA helps here in two ways. First, Sword-on-Shield assessments, identifying key technical characteristics desired in weapon systems, act as a broker between technological advance and systems which suffer a deficiency because of a limit in that technology. Second, technological comparison, NTA may reveal clever ideas of the adversary which could contribute to our technology base. Since the first contribution is a "spin-off" and the second could come about through intelligence activities alone (without the comparison), NTA must be considered only a secondary contributor in implementing this principle.

---

[1] Statement by the Director of Defense Research and Engineering, Dr. John S. Foster, Jr., on the Fiscal Year 1973 Defense RDT&E Program before the Armed Services Committee, U.S. House of Representatives, 92nd Congress on 29 February 1972.

PROGRAM PLANNING: The importance of correct program definition is emphasized in principle 3. Guidance in system concept synthesis toward the correct "blend" of technical performance characteristics is a direct result of Sword-on-Shield NTA. For this part of the implementation, NTA can be key. NTA can be a primary contributor in implementing this principle.

VIABLE OPTIONS: One component of principle 4 is "Forcing . . . consideration of alternative paths to the same goal." Like weapon comparison NTA exposes alternative means to mission accomplishment which may not be conceived by the U.S. weapon designers because of "tradition" of design philosophy. Since these "ready-to-wear" alternatives are concepts that have been designed and demonstrated they are viable and represent a valuable input to the implementation of this principle.

COMPETITION: NTA has no readily discernible role (apart from the generation of alternatives already discussed) in implementing principle 5.

SELECTIVITY: Selectivity requires choice and rational choice requires a decision rule. Sword-on-Shield NTA provides a performance criterion both for the design of test and evaluation experiments and for rational decisionmaking when the number of viable options must be limited. NTA serves well in exercising principle 6.

PROGRAM MANAGEMENT: Program management is allied with R&D direction more than with planning. NTA has no obvicus role in helping to improve this aspect of the process.

ASSESSMENT OF NEEDS: Sword-on-Shield NTA with its emphasis on identifying technical deficiencies is a "natural" for defining Advanced, Engineering, and Operational Development objectives. Side-by-Side NTA, though less specific in pointing the way, aids in directing program thrust in the Research and Exploratory development categories. It is in the

effective implementation of this principle that NTA can make its greatest contribution to R&D planning.

DESIGN-TO-COST: In implementing this principle the designer must maximize performance under a cost constraint. Maximization requires the existence of a criterion or objective function and also--to be meaningful--the availability of admissible (satisfying the constraints) design alternatives. Side-by-Side NTA as a generator of alternatives, either at the techniques level or at the component or subsystem level, has been discussed above under "Viable Options." The concept applies equally well here. The applicability of Sword-on-Shield NTA to generating objective functions was described also under "ROI Consciousness," "Program Planning," and "Selectivity." Certainly NTA can play an essential role in design-to-cost guidance.

INDEPENDENT RESEARCH AND DEVELOPMENT: While independent research and development is by definition not planned, organized, directed, or controlled by DOD, there is a requirement[1] that the objectives have relevance to DOD needs in order that the expense be potentially allowable in the contractor cost structure. Dissemination of the needs, deficiencies, and potential areas of technological surprise determined by NTAs to industry would tend to focus this important complement to the DOD R&D program onto goals of greater benefit to DOD and the nation. Since retaining the independence of this effort is requisite to its role, the efficacy of NTA is uncertain and we can count its contribution as only secondary.

2. General Comments

It should be clear at the outset that neither the "Principles" as stated nor any means of implementation would be necessary if there were

[1] PL 91-441 as implemented by ASPR 15.205.35.

unlimited R&D budgets. It is attempting to operate under economic constraints that gives rise to the underlying issue of this paper.

I have outlined a respectable case for the use of NTA in implementing the Principles for DOD Defense Research and Development. However, it is not evident that NTA in its present state is achieving anywhere near this potential. This raises questions of what is wrong with the above assertions and/or the system.

The DDR&E NTA office is a small organization (~ six people) with a budget of a few million dollars. Steering an 8 billion dollar barge is not feasible with a rudder that small. So we have to consider the project in the experimental or pilot stage and look at the microcosm. There have been some significant effects on DDR&E program planning as a result of NTA studies. Dr. Foster attributes several R&D thrusts in the FY 1973 proposal to previous NTA studies.[1] The development of the USAF Light Weight Fighter is cited also as a consequence of an NTA-like study.

Is NTA the panacea for all R&D planning? Obviously not. It has no contribution toward some of the "Principles" and offers only partial solution to the implementation of others. The firm requirement for valid, independent, technical data on the adversary elements rules out its use where these data do not exist.

For the most valuable Opposing Weapons Engagement and Opposing Force Unit Engagement types, pro forma studies are difficult because, in essence, the design decisions have to be made to characterize the weapon systems and the tactics. But these studies should be particularly valuable for DSARC decisions, if alternatives are available from which to choose. At these points in the development, mission application and design concepts have firmed up.

---

[1] Foster, op. cit.

Technology and Weapons Comparison studies have less well defined applications. As noted above, clever ideas of the adversary may fall out. They may reveal also the direction of planned operational equipment improvements such as day-to-night, clear-air-mass capability vs. day to adverse weather capability depending on what is being pushed in their research and exploratory development equivalents. Comparative studies also provide a good background for the more complex Opposing Weapons/Forces types. All of these results and benefits could come out of straight intelligence activities. Comparative studies, though, provide a reference (the U.S. Technology/System) to direct attention to differences and saliencies.

In the language of Management-by-Objectives, the activities of R&D planning can be divided into routine, problem solving, and innovative. Routine activities (if this term can be used in connection with R&D at all) would be concerned with schedule and costs and making expected decisions by a-priori rules in ongoing programs. Problem solving would be required when these things depart from plan and new decisions with regard to schedules, costs, or performance are required. Innovation implies new programs and new procedures--a change in the way of doing business. Introduction of NTA into R&D planning is of course innovation in itself. But assuming it is in place, how would the different kinds of NTA impact on these classes of management activity? The guidelines for routine decisions should be influenced by Sword-on-Shield NTA results as would problem solving. In fact, the problems might arise as a consequence of NTA. Innovation of new programs or new techniques (in design, not management) might be expected from comparative NTAs.

NTA has been considered expensive. All analysis is expensive in some frames of reference. The alternative is to substitute judgment or opinion. NTA contributes to judgment and in the process builds an analytical base which will enable shorter response time (an essential requirement) with consequent cost reduction. Even where time constraints force resort to judgment, more accurate judgments will ensue. Even minor improvements in R&D efficiency (achievement of correct, thus more valuable, goals) would justify large increases in analytical effort on an ROI basis.

But why NTA? It was pointed out that NTA has some unique features that set it apart from other technical analysis. NTA is an organizing device bringing together the R&D and intelligence communities. It sharpens the questions and directs inquiry toward more useful ends. In short, it is a way (but not uniquely so) of producing better analysis.

However, analysis is not enough. Analysts (in general) shy away from advocacy to protect their objectivity. They assume that in the absence of criticism of their data selection or model, their results are correct and any rational, value-maximizing, informed decisionmaker will implement their recommended solution. They are wrong. Analysis is never perfect. Decisionmakers are never completely rational in the analysts' frame of reference. (They are usually maximizing an objective function of additional complexity.)

Unfortunately the DOD R&D community is a political/organic/economic system which has many internal forces and subvalue systems; which is constrained to respond by learned routines; and in which conflicting subgoals dilute the "team effectiveness." In other words, it has the real-life nonmonolithic characteristics of any other large organization.

Therefore even producing outstanding net technical assessments is not enough. The responsible analyst must follow through. His recommended solution must be introduced into an action agenda and backed by key players who are strong advocates before the NTA benefits are realized in practice. Perhaps this role could be promoted by the DDR&E-NTA office, and the analyst must realize in this process that the "acceptable" solution may be transformed by these other, always-present forces to be different from the solution originally offered.

Notwithstanding this pessimistic note, NTA needs to be done and done well. It should produce the normative goals about which the fluctuations are minimized by executive control. One can conclude with respect to the question at the beginning of these general comments that the

assertions are valid and the system is real--just not analytically ideal. The acceptance and general use of NTA as a Defense R&D planning tool will take more time.

E. Summary of Findings

An estimate of the potential of NTA to contribute to R&D planning can be obtained by viewing NTA's possible roles in implementing the Principles for Department of Defense Research and Development (Table 3.1). This approach yields a score of primary contributions in implementing 6 of the 10 principles, secondary contributions in 2 cases, no contribution in 1 case, and not relevant in 1 case. Thus in something like 7 of the 10 objectives NTA has something to offer toward their achievement. However, in no case is NTA by itself the solution.

It is asserted that NTA is still embryonic but has demonstrated value in some specific cases and will increase in value as the data base and techniques develop. NTA does not apply universally to all R&D activities. It is of greater value in the middle stages of projects where technical characteristics are available but decisions are not frozen. NTA has something to contribute in all planning management activities--routine, problem solving, and innovative.

NTA represents a unique approach with its own values. To realize these values, however, it needs advocacy to bring its worth to executive attention.

THE DETERRENT ROLE OF DUAL CAPABLE GENERAL PURPOSE FORCES--THE TECHNOLOGICAL CONTRIBUTION

by

W. Lackman

THE DETERRENT ROLE OF DUAL CAPABLE GENERAL PURPOSE FORCES--
THE TECHNOLOGICAL CONTRIBUTION

SUMMARY

The advent of strategic parity, the pressures toward nuclear proliferation, the increasing sophistication of the modern battlefield, and the likelihood that the armed forces of the United States and its allies will be faced with numerically superior and increasingly heavily armed opponents demands a deterrent posture based on a credible dual-capable force. Although U.S. general purpose forces are currently configured for both conventional and nuclear warfare, their posture remains essentially a grafting of first-generation nuclear weapons on a conventional force. This presents an undesirable dichotomy because of the necessity of massing forces in conventional warfare and dispersing them in nuclear warfare.

Several technological developments promise to make possible a convergence of conventional and tactical nuclear force postures which would eliminate the dichotomy between the requirements for massing and dispersal. The most important is the development of precision-guided munitions (PGM), which offers the promise of greatly increasing the effectiveness of conventional munitions by reducing substantially the expenditure rates per casualty. Elimination of registration, ranging, and bracketing techniques assures surprise and maximum damage before the target takes passive or evasive protective measures.

The application of precision-guidance techniques to a wide range of systems--artillery, antitank missiles, bombs, and rockets--offers the possibility of improved conventional effectiveness with lower manpower densities, thereby affording a measure of passive protection against enemy use of nuclear weapons.

PGMs also offer promise of using tactical nuclear weapons with greater effectiveness and selectivity, thereby reducing collateral damage. Much of the concern for initiating the use of tactical nuclear weapons in a theater such as Europe is based on the concern for the nonmilitary casualties and damage which would result from the combination of system inaccuracies and the compensating high yields of the weapons in the current inventory. With terminal guidance, the technology exists to transform the existing stockpile of relatively large and "dirty" tactical nuclear weapons into a family of weapons tailored to meet specific target needs and potentially capable of producing less collateral damage than would be produced by the random massed conventional bombing or artillery fires of World War II-type operations.

The exploitation of precision guidance and improvements in weapon effects--both nuclear and nonnuclear--would be particularly effective in negating the probable numerical superiority of future opponents. Technology must, however, provide improvements in several related areas for this potential to be fully realized. Great strides have already been made in some areas such as night vision devices, which have greatly increased capabilities for target acquisition and engagement. In spite of these developments, however, target acquisition on the battlefield remains essentially line-of-sight and clear air. Remote weaponry such as artillery and missiles will only be able to exploit the potential of precision guidance when continuous, preferably remote, collection systems permit target identification with sufficient precision to permit placing the PGM within the envelope of its terminal guidance in any weather and visibility conditions.

Hand-in-hand with improved target acquisition, the new weapons and doctrine call for improvements in command, control, and communication. The use of dispersed formations of small semi-independent units makes essential an adequate flow of information over secure and redundant circuits, and improved target acquisition and precise means of delivery require a rapid system of fire control in order to engage fleeting targets.

A posture that couples the precision-guided conventional munitions, the reduced battlefield troop densities, and the improved conventional warheads that are already with us with small tailored-effect tactical nuclear weapons would constitute a truly dual capable force. Such a force would not only raise the nuclear threshold, but also, more importantly, have a synergistic effect on the deterrence of both nuclear and nonnuclear aggression. The uncertainty of success felt by a potential aggressor coupled with the uncertainty of escalatory risk represented by his opponent's credible nuclear capabilities will add to the stability of areas of possible conflict such as Europe.

THE DETERRENT ROLE OF DUAL CAPABLE GENERAL PURPOSE FORCES--THE TECHNOLOGICAL CONTRIBUTION

William Lackman

A. Purpose

The purpose of this paper is to investigate the role of technology in improving the deterrent value of dual capable general purpose forces.

B. Background

Since the 1950s and the development of Soviet nuclear capabilities, it has been part of the U.S. strategic posture to maintain a full range of nuclear and nonnuclear capabilities to deter and if necessary defend against all manner of aggression. Though arguments abound about the relative emphasis to be placed on the conventional and nuclear components of the strategy, a requirement remains for structuring U.S. general purpose forces for either a nuclear or nonnuclear battlefield, i.e. dual capable forces.

The requirement for dual capable forces stems from two fundamental premises. First, there exists a significant nuclear arsenal in the hands of potential aggressors who retain the capability to initiate nuclear operations unless deterred from doing so. Although this potential is greatest in Soviet forces, there are other powers possessing less extensive and sophisticated capabilities which are sufficient to create a nuclear threat to U.S. forces. The explosion of the Indian device, while not signaling wholesale proliferation, does create uncertainty as to how many nations might feel impelled by political or security circumstances to acquire nuclear weapons. Looking ten to twenty years ahead, we must consider that any military operation could be influenced by the threat of or use of nuclear weapons.

The second premise derives from the first--namely, that the way to deter the use of nuclear weapons is to deny the prospective user the advantages to be gained from their use. If U.S. forces are capable of surviving and operating successfully in a nuclear-scared environment the incentive to use tactical nuclear weapons is removed. While the deterrence of the aggressor's introduction of tactical nuclear warfare is the first function of U.S. tactical nuclear capabilities, such capabilities also add to the deterrence of conventional aggression. A credible U.S. capability to employ tactical nuclear weapons in the event a conventional defense is failing prevents a potential aggressor from clearly calculating a priori that he can gain conventional superiority and hence an easy victory. Uncertainty of success and a perceived risk of undesirable escalation thereby contribute to the deterrence of nonnuclear as well as nuclear attack.

C. Statement of the Problem

While U.S. general purpose forces are currently configured for both conventional and nuclear warfare, their posture remains essentially a grafting of first generation nuclear weapons on to an essentially conventional force. This presents some undesirable dichotomies which appear to be solvable with evolving technology. The principal dichotomy results from the necessity to mass forces in conventional warfare and disperse them in nuclear warfare. The limitations of conventional arms have placed a premium on mass formations in order to achieve firepower advantage. This not only has been a result of the lethality of conventional weapons but also is a function of accuracy, rates of fire, range, and command and control. First generation tactical nuclear weapons so increased potential lethality that problems of accuracy, rates of fire, and command flexibility appeared to be insignificant. Survival of conventionally configured forces seemed impossible, as did the survivability of the population and infrastructure of the potential battlefield. As long as the United States maintained strategic nuclear superiority, nuclear escalation created sufficient uncertainty to extend deterrence downward to include tactical nuclear and conventional warfare as well.

With the existence of strategic parity, a greater attention must be paid to the credibility of the U.S. deterrent posture at lower levels of warfare. Several technological developments promise to make possible a convergence of conventional and tactical nuclear force postures eliminating the dichotomy between the requirements for massing and dispersal. If this can be accomplished, not only would the deterrent posture of dual-capable general purpose forces be improved, but the nuclear threshold would be raised if war should occur. How technology can contribute to this development is discussed below.

D. Discussion

The advent of strategic parity, recognized officially in the 1972 Moscow accords, has set off a new round of discussions in NATO over the adequacy of allied forces. The Soviet Union and its Warsaw Pact allies have always enjoyed numerical superiority in land and air forces employable in Central Europe. Some of the assessments are quite dire, attributing to the Warsaw Pact superiorities of as high as 3 to 1 in tanks, 2 to 1 in tactical aircraft, and 3 to 1 in artillery. Adding to the concern is the Soviet assumption of the offensive employing massed armor penetration tactics in a limited sector of the front to permit rapid exploitation by followup echelons in the rear of Allied defenses. Balancing this is a distinct allied qualitative superiority in aircraft, antitank weapons, and logistic support. To the pessimistic the net assessment of these factors results in either a NATO conventional defeat or an early resort to nuclear weapons. To the optimistic, qualitative NATO advantages suggest a good chance of a conventional defense with some relatively minor improvements in NATO force posture. In either view there is agreement that NATO forces, for both political and economic reasons, cannot and should not attempt to match the Warsaw Pact tank-for-tank and man-for-man.

What is called for is the derivation of a defense concept which negates the likelihood of a rapid Warsaw Pact success in a blitzkrieg-style attack in Central Europe at either the nuclear or nonnuclear level. This entails

a parallel development of doctrine for dual capable forces and the exploitation of technology. Although the Warsaw Pact/NATO confrontation poses the most severe challenge to doctrine and technology, the proliferation of sophisticated weapon systems, especially in the Middle East and South Asia, as well as the likely proliferation of nuclear capabilities in the decade ahead, suggests the applicability of such doctrinal and technological developments to any contingency U.S. forces might confront.

In assessing ways in which technology can bring about a convergence of tactical nuclear and conventional capabilities of general purpose forces, accurate delivery of munitions assumes a top priority. The development of precision guided munitions (PGM) may be the most significant development of modern warfare. In the first instance it offers the promise of greatly increasing the effectiveness of conventional munitions. The Vietnam war provides a graphic illustration of the potential value of PGM. For years, efforts were made with iron bombs to knock out the Paul Dormer bridge, a major link in the North Vietnamese north-south transportation system, without success. With the introduction of first generation "smart bombs," it was knocked out on the first try.

In the land battle, artillery is of course a main antipersonnel weapon of the defender. Analysis of World War II, Korea and Vietnam experience has revealed expenditure rates of from 300 to 340 rounds per casualty. PGM offer the prospect of reducing these rates significantly with greater shock and casualty effect by insuring first-round effectiveness. Elimination of registration, ranging, and bracketing techniques assures surprise and maximum damage before the target takes passive or evasive protective measures. PGM also makes artillery an effective weapon against hard pinpoint moving targets such as tanks and APCs which it is not now because of its innate inaccuracy and fixed trajectory.

The application of precision guidance techniques to a wide range of systems--artillery, antitank missiles, bombs, and rockets--offers the possibility of improved conventional effectiveness with lower manpower densities, thereby affording a measure of passive protection against enemy use

of nuclear weapons. The reduced ammunition requirement associated with PGMs also reduces the logistical support requirement of the theater--a significant savings in manpower and money--but also simplifies the dispersion of logistic facilities for reduced vulnerability to nuclear attack.

Although PGMs hold the promise of rendering obsolete the enemy's reliance on massed attack formations and hence raising the nuclear threshold, they also offer promise of using tactical nuclear weapons with greater effectiveness and selectivity with reduced collateral damage. Much of the concern for initiating the use of tactical nuclear weapons in a theater such as Europe is based on concern for the nonmilitary casualties and damage which would result from the combination of system inaccuracies and the compensating high yields of the weapons in the current inventory. With terminal guidance, the technology exists to transform the existing stockpile of relatively large and "dirty" tactical nuclear weapons into a family of weapons tailored to meet specific military target needs:

- Yields as low as 20 to 50 tons of TNT are possible (compared to 10-100 KT for the majority of the current stockpile). With pinpoint accuracy such yields are adequate for all but the hardest military targets.

- Enhanced radiation weapons are possible which produce casualties to personnel through a burst of neutrons and gamma rays lasting a fraction of a second, without blast or heat damage to buildings.

- Suppressed radiation weapons reduce fallout so that low-yield weapons can be used to destroy relatively small hard targets such as nuclear storage sites or underground command posts.

- Induced radiation weapons produce short-term radioactivity which can be employed to deny critical terrain to the enemy without long-term or extended downwind contamination.

Weapons tailored in this manner as to yield and desired weapon effects would permit a use of nuclear weapons tailored to the desired effect with potentially less collateral damage than would be produced by the random massed conventional bombing or artillery fires typical of World War II-type operations.

The posture that couples precision guided conventional munitions, reduced battlefield troop densities and improved conventional warheads that are already with us with small tailored-effect tactical nuclear weapons--i.e., a truly dual capable force--will not only raise the nuclear threshold but, also, more important, have a synergistic effect on the deterrence of both nuclear and nonnuclear aggression. The uncertainty of success felt by a potential aggressor coupled with the uncertainty of escalatory risk represented by credible nuclear capabilities will add to the stability of areas of possible conflict such as Europe. As Secretary Schlesinger has pointed out, "the decision to initiate the use of nuclear weapons--however small, clean, and precisely used they might be--would be the most agonizing that could face any national leader." Introducing that agonizing decision into the calculations of the potential aggressor is the deterrent value of dual capable general purpose forces.

The exploitation of precision guidance and improvements in weapon effects--nuclear and nonnuclear--have the greatest potential payoff in negating the probable numerical superiority of future opponents. Technology can and must provide improvements in several related areas for this potential to be fully realized. First, to gain full effectiveness from precision guided munitions, improvements must be made in intelligence and target acquisition. Great strides have been made in some areas such as night vision devices which have greatly increased capabilities for target acquisition and engagement. Because of Soviet doctrine for continuing operations on a twenty-four-hour basis, this is an extremely significant capability which must continue to be improved in quality, range, cost, and flexibility of application. In spite of these developments, however, target acquisition on the battlefield remains essentially line-of-sight and clear air. Although airborne platforms extend the range of this line-of-sight capability, their increasing vulnerability in a sophisticated air defense environment, relatively short stay time, and limited viewing horizon are serious constraints. Remote weaponry such as artillery and missiles will only be able to exploit the potential of precision guidance when continuous, preferably remote collection systems permit target identification with sufficient precision to permit placing the PGM

within the envelope of its terminal guidance in any weather and visibility conditions. Early endeavors with remote sensors (ground and airborne) and remotely piloted vehicles indicate that the depth of vulnerability of the attacking force can be extended from the present 3-5 kilometers (with intermittent patchwork air-determined areas of vulnerability) to considerably greater depth. Denial of safety and freedom of movement of reserves, logistic formations, and follow-on formations are as important to the defense in modern warfare as front-line defensive capabilities. Weapons systems are now improved enough to deny the enemy sanctuary if we develop the capability to find his forces.

Hand-in-hand with improved target acquisition, the new weapons and doctrine call for improvements in command, control, and communication. Dispersed formations of semi-independent and smaller units call for improved information flow over secure and redundant circuits. Improved target acquisition and precise delivery means require rapid means of fire control in order to engage fleeting targets. The intensity of combat on the modern battlefield especially in the initial phase requires doctrinal and equipment capabilities more rapid and accurate than ever before. Finally, the complex electronic warfare environment which can be expected on the future battlefield must be overcome. Modern technology embodied in microminiaturization, automatic switching, burst transmission, hardening, and plug-in maintainability can meet these strenuous demands. The challenge is to develop the doctrinal framework and simplicity of hardware design to put the technology in the hands of troops.

Although this paper has stressed the application of precision delivery techniques and tailored weapon effects because of their potentially revolutionary effect on the future deterrent posture of U.S. dual capable general purpose forces, the modern battlefield will continue to demand improvement in areas such as the following:

- Tactical and strategic mobility
- Inexpensive and simple conventional weapons for such purposes as antiair and antitank defense

- Improved range of indirect fire weapons such as artillery and missiles

- Aircraft and missile systems which can be made more survivable both from attack on the ground and when operating in a sophisticated air defense environment

- Systems and equipment which are less demanding of maintenance and other logistical support.

E. Summary of Findings

The advent of strategic parity, the increasing sophistication of the modern battlefield, and the likelihood that the United States and its allies will be faced with numerically superior and increasingly heavily armed forces demands a deterrent posture based on a credible dual capable force. Technology, particularly in the areas of precision guided munitions and tailored weapon effects supported by near real-time target acquisition and responsive, survivable command and control, can, when married with innovative tactical doctrine, bring into being forces capable of a higher level of conventional defense than at present, while posing credible tactical nuclear deterrent. The net result would be a stronger deterrent to any aggressive move by potential enemies, either nuclear or nonnuclear.

TECHNOLOGICAL SUPERIORITY--IS IT A VIABLE DEFENSE R&D OBJECTIVE?

by

R. C. Wakeford et al.

TECHNOLOGICAL SUPERIORITY--IS IT A VIABLE DEFENSE R&D OBJECTIVE?

SUMMARY

In spite of the need for U.S. superiority in defense technology, the technological lead which the United States has enjoyed over the USSR is diminishing. This paper considers the question of measuring technological superiority and proposes steps to be taken so that the United States can maintain an advanced technological base under current economic conditions by increasing the coupling between U.S. defense and consumer technologies.

Comparisons of the military effectiveness of fully developed and deployed weapons systems are of little use to the R&D planner, since he is concerned with systems that may be deployed in the future. What is significant is the comparison of the technological bases from which the future systems may be derived. Because the USSR shrouds its military development program in great secrecy, technological comparisons, per se, do not provide the R&D planner assurance that the future military potential of the USSR can be foreseen or anticipated. The most useful basis for comparison is therefore the "advanced technological base," which assumes that technology incorporated into manufacturing processes represents late technology.

The existence of a technological base in any area of technology reflects a considerable investment of national resources: skilled manpower, funds, and material, and the upgrading of a technological base to more advanced technologies requires a sizable additional investment of these resources and--most significantly--it requires time. In the United States, nondefense programs, such as the space program, have made significant contributions to the growth of the technological base. This advanced technological base provides the U.S. planner with the mechanism for responding to a technological surprise. The short leadtime offered by an advanced

technological base assures that a military advantage gained by an unpredicted advance in Soviet military technology can be overcome quickly. It also reduces the possibility of a technological surprise.

In the current economic climate in the United States, resources for defense R&D are limited; therefore the Department of Defense must look to other sources for technological development. One of these sources, U.S. consumer technology, would be a logical focus of attention, for therein lies a great advantage to the United States over the Soviet Union. The U.S. industrial base provides a vast pool of scientists, technicians, and managers seeking new products and finding more efficient ways of producing them--a pool that produces improved military equipments as well as civilian consumer products. It is essential in today's environment for U.S. defense planners to seek ways to enhance the development of this consumer-generated, defense-related technology. To accomplish this, the DOD should undertake programs to reduce the classification of military technology, to increase the awareness by industry of military needs, to use industry more freely in military logistics and other similar programs, and to more closely couple American military technology to the civilian consumer industry.

TECHNOLOGICAL SUPERIORITY--IS IT A VIABLE DEFENSE R&D OBJECTIVE?

A. Purpose

This paper examines the concepts of technological superiority and technological parity and evaluates their applicability to the planning of the Defense R&D Program.

B. Background

The maintenance of technological superiority has been used as a rationale for the U.S. Defense R&D Program. Secretary of Defense Laird stated to the Congress, "if the United States ever decides we cannot afford to maintain technological superiority, then we must be willing to accept the status of a second rate power. And that, Mr. Chairman, I do not believe the American people are prepared to accept."[1] A year later Dr. Currie, DDR&E, stated, "American security, like the American economy, stands on a foundation of technological superiority. We need superiority in defense technology."[2]

In spite of the need for U.S. superiority in defense technology, DOD officials recognize that the technological lead which the United States has enjoyed over the USSR is diminishing. In 1973, Dr. Foster reported to the Congress the results of the DOD Net Technical Assessment (NTA).[3] The assessment concludes that although the United States enjoys an overall technological

---

[1] "Final Report to the Congress of Secretary of Defense Melvin R. Laird," before the House Arms Services Committee, 8 January 1973.

[2] "The Department of Defense Program of RDT&E, FY75," statement by the DDR&E to the 93rd Congress, 2nd session 1974, 26-27 February 1974.

[3] "The DOD Program of RDT&E, FY74," statement of the DDR&E to the 93rd Congress, 1st session 1973, 28 March 1973. (Hereafter referred to as DOD Program, FY74.)

superiority over the USSR, the United States has specifically achieved technological superiority in only a few areas of military technology; the United States and the USSR are approximately equal in a number of areas and the United States is relatively inferior in others. Furthermore, Dr. Foster pointed out that the Soviet level of effort in military technology is increasing while the U.S. effort is declining. Subsequent to Dr. Foster's statements, DOD appropriations have been further reduced and thus U.S. maintenance of overall technological superiority will be more difficult in future years.

SALT agreements to date have focused on quantitative limitations on weapons systems but there are proponents for extending the negotiations into qualitative considerations.[1] If qualitative limitations should be agreed, technological parity of deployed strategic weapons systems could evolve. MBFR negotiations could similarly extend technological parity to general purpose forces.

C. Statement of the Problem

In the light of the current economic, political, and military climates, it is pertinent for defense R&D planners to consider whether technological superiority should remain as an R&D objective. Continued effort by the United States to achieve and maintain technological superiority not only may be impractical within the limitations of the U.S. defense R&D resources but also may lead to a free-running technological competition between the United States and the Soviets, comparable to an arms race.

---

[1] "Contrasting Approaches to Strategic Arms Control, Appendix A: The Qualitative and Quantitative Dimensions of Arms Control: Implications for Technological Innovation for SALT II--Report on a Panel Discussion" (Lexington Books, D.C. Heath and Company, 1974).

On the other hand the maintenance of technological superiority may not be a necessary objective. Technological parity is suggested as an alternative U.S. objective that should be considered. This raises the issue of whether the U.S. military posture would be degraded in the absence of technological superiority.

This paper examines the viability of technological superiority as a U.S. defense R&D objective vis-a-vis technological parity. It considers how an advanced technological base can be maintained in the current economic climate by increasing the coupling between U.S. defense and consumer technologies.

D. Discussion

If technological superiority, or technological parity, is to be the objective of defense R&D, the meaning of this term should be understood by R&D planners who must translate it into meaningful program guidance.

Three connotations of the term technology can be identified in DOD usage: scientific knowledge,[1] industrial know-how,[1] and performance characteristics of military weapons systems[1] and military forces.[2] In common use technology refers to applied science and signifies industrial capability achieved through the application of scientific knowledge and methods to industrial processes. Thus scientific knowledge and industrial capability constitute a technological base from which military technology, i.e., military weaponry, is derived. Whatever sense is intended by technology, the term technological superiority implies that technologies can be compared to determine which is superior, equal or inferior.

---

1 DOD Program, FY74.

2 Sullivan, Deputy DDR&E, Address Before the AFMA (Air Force Management Association)/NSIA (National Security Industrial Association) Symposium, 16 August 1972.

Quantitative comparisons of range, destructive power, accuracy, mobility and the like can provide measures of the military effectiveness of weapons systems. The military effectiveness of combined weapons systems and forces can be estimated by operational analysis and war gaming. Hence reasonably accurate comparisons of military technology can be made where the characteristics of weapons systems are known. Unfortunately, intelligence of Soviet weapons systems is scant until the systems have been tested, deployed, or committed. Moreover, comparisons of the military effectiveness of fully developed and deployed weapons systems, although providing useful information to the defense planner, do not fulfill the requirements of the R&D planner. The latter must be concerned with systems that may be deployed in the future. Hence he must attempt to make comparisons of the technological bases from which they are derived.

Scientific knowledge is not amenable to quantification and is difficult to compare in gross. NTA estimates are based on identifying areas of technology of military significance and making subjective comparisons of the available information on Soviet and U.S. applied science in each of these areas. These separate estimates are combined to give an overall appraisal of Soviet applied science in comparison with that of the United States. Industrial technology is largely inferred from the quality and quantity of items produced. Product comparison data in themselves are after-the-fact from the viewpoint of the R&D planner. In any event NTA comparisons are largely based on subjective judgments and are highly dependent on intelligence. Because the USSR shrouds its military development program in great secrecy, technological comparisons, although highly significant, cannot be considered as providing the R&D planner assurance that the future military potential of the USSR can be foreseen or anticipated. For this reason the term <u>technological parity</u> has little meaning when applied to the technological base although gross differences could account for technological superiority or inferiority. A more appropriate term is <u>advanced technological base</u>, which assumes that technology incorporated into manufacturing processes represents late technology.

The existence of an advanced technological base in any area of technology represents a considerable investment of national resources: skilled manpower, funds and material. The upgrading of a technological base to more advanced technologies requires a sizable additional investment of these resources and most significantly it requires time. The DOD made large expenditures in time and money to provide an industrial capability for the manufacture of advanced technology electronic parts for the Safeguard Program. The industrial capability developed for the Safeguard Program has contributed to other weapons systems, by reducing the cost and leadtime for procuring electronic components. Nondefense programs, such as the space program, have made significant contributions to the growth of the U.S. technological base to its present strength. This technological base, in far-ranging areas of technology, provides the defense planner with the mechanism for responding to a technological surprise. The short leadtime offered by an advanced technological base assures that a military advantage accrued by an unpredicted Soviet military technology can be overcome quickly. It also reduces the possibility of a technological surprise occurring.

Scientists, engineers, military commanders and defense planners cannot estimate the military potential of an undeveloped technology. To expect them to do so would be to expect them to have anticipated the military potential of radar or atomic fission in 1930. It was only after a decade of research and development that the full significance of these technologies could first be estimated. A broad-based research and development program is required to identify those areas of technology which offer new weapons or new military technology.

An advanced technological base provides a constant flow of concepts for new weapons systems--not all of which can be exploited because of resource limitations. The decision as to which weapons systems should be exploited is the most critical one to the R&D planner. It involves the interplay between military requirements and technological possibilities.

"The United States and the USSR have different philosophies of military technology: the USSR focuses on continuing growth in small steps, while the United States is more inclined to reach for less frequent but larger steps toward improvement."[1] The U.S. defense planner selects from among those capabilities offered by new technologies those which offer an order of magnitude improvement in the U.S. military capability relative to that of our potential enemies. This selection must be made early enough to avoid technological inferiority in U.S. forces, recognizing the production/deployment leadtime. In making this selection the R&D planner has full knowledge of U.S. national policy and strategy, military plans, force deployments and existing force capabilities, but he must rely on incomplete intelligence estimates of the Soviet military capabilities.

The USSR planner may elect to apply military technologies in a manner which differs from the U.S. developments and has done so in the past. The Soviets rely on heavier throw-weights in ICBMs, the Soviets make more extensive use of ground-to-ground rocket artillery, and the Soviets exploit electronic warfare more fully. Even an equal technological base will not result in an equivalent exploitation of military possibilities offered by technology. Even a superior technological base will not guarantee that a superior military technology will evolve. But the likelihood of this happening is increased by a superior technological base.

A consequence of the action/reaction development of military technology could be a technological race, if indeed one does not already exist. In the current economic climate the U.S. resources for defense R&D are limited; therefore the DOD must look to other sources for technological development. One of these sources, U.S. consumer technology, would be a logical focus of DOD attention for herein lies a great advantage to the United States over the USSR.

---

1 DOD Program, FY74.

The American people today enjoy the highest standard of living in the world when measured by the convenience provided by the products used in their daily life. These superior products have resulted partly from our great supply of natural resources but primarily from American ingenuity in adapting science to useful purposes. These products have been enabled by the U.S. institutions in government and society. Industrial competition and a relatively uncontrolled economy have permitted American consumers to demand better products and obtain them, impelling Americans to develop techniques to produce the maximum from American resources. Although all free-world economies are currently plagued by a shortage of energy resources, there is little doubt that American ingenuity in science and technology will overcome this obstacle and will ultimately lead the United States to an even greater industrial base superiority over all other nations of the world--particularly over those in the Sino-Soviet bloc.

The U.S. industrial base provides a vast pool of scientists, technicians and managers seeking new products and finding more efficient ways of producing them--a pool which produces improved military equipments as well as civilian consumer products. Competition among our industrial concerns ensures efficiency in our industrial processes and results in a nearly continuous flow of incremental improvements. The demand for superior American products overseas serves as an incentive for American industry to manufacture equipment which will function in the environmental conditions of all developed areas of the world. The consumer market demands to a large part items which are used by military forces, excepting items of specialized military application such as nuclear warheads and delivery systems. Thus in the U.S. industrial complex lies the foundation of American military technological superiority.

Defense research, development and production contracts to capitalize on the American industrial capacity will be fewer in the near-term austerity of defense funds. It is logical in today's environment for defense planners to seek ways to enhance the development of consumer-generated, defense-related technology. They should accentuate programs which will increase the coupling between military technology and consumer products.

A principal factor inhibiting the free interchange of technology between consumer-oriented industry and defense industry is the classification of military technology. Classified defense technology is available only to those industrial concerns possessing DOD facility clearances and is applicable only to military equipments. Classifications assigned in the past were derived when government was prone to disguise its operations from the public in the interest of national defense. Today the United States is confronted with new political considerations in both the domestic and international areas. Greater visibility of governmental operations in the American public is required of public officials and is forcing a reconsideration of the use of classification of information. The prosecution of detente has resulted in negotiation with potential enemies on matters previously hidden by secrecy. This atmosphere suggests that some benefit may accrue in the interest of national defense by reviewing the presently classified defense technology in an effort to provide the consuming public the benefits of this technology. Furthermore the expenditure of defense research funds could be made more acceptable to the American taxpayer if he were made fully aware of the numerous nonmilitary products made possible by their expenditure.

Industrial corporations of the United States are not at all unaware of the significant contributions that their own internal research programs make to national security. Although these contributions can be stimulated by defense contracts, many are prosecuted by the corporations, using their own resources, if they are fully aware of defense needs. Because they are profit oriented, they seek a return on their investment through defense production contracts as well as civilian product improvement. The DOD could assist corporations in this endeavor by providing effective liaison with industry to provide for a free interplay of ideas on the military potential of new technological developments.

A constraint on the transfer of civilian products to military use is the stringent specifications placed on military equipment as regards ruggedness, reliability, transportability, ability to function in environmental extremes, ability to be operated with minimum training of operating military

personnel, and the like. Although such military-peculiar specifications may have been justifiable in the past, the need for them today is decreasing. Worldwide transportation of consumer goods via cargo aircraft, operation and storage of these commodities in varied climatic conditions, and the use of U.S. products by consumers of other nations is converging the specifications of consumer products towards those which are militarily acceptable. A review of military specifications in the light of today's environment, today's deployments, today's military plans and today's consumer products could decrease the difference between military equipment and its civilian counterpart. In some instances the acceptance of commercial standard equipment, even though somewhat inferior to military equipment, could be in the overall defense interest.

There are possibilities for American industry to play a greater role in military logistics. The complexity of modern military materiel, especially that involving electronics, is so great that highly skilled technicians and highly specialized facilities are required to perform repair. Maintenance of sophisticated equipment at forward military echelons consists mainly of replacing defective subassemblies. Cost effective repair can best be performed at depots where the required skills and machinery can be concentrated for production line operations. Modern aerial transportation makes possible the evacuation of these subassemblies to U.S. industrial plants for production line repair and testing. The elimination of high-specialization skills, parts stockage and expensive machinery from the military logistics system would result in considerable savings of DOD funds.

Managers with the responsibility for the administration of U.S. research and development programs and logistics programs can undoubtedly contribute other ideas to increase the coupling of defense programs with consumer industry. The prosecution of such ideas would permit the DOD to more effectively exploit the ability of American industry to fulfill defense requirements.

E. Summary of Findings

The political, military and economic developments of recent months are significant enough that R&D planners should examine the goals and objectives of their programs to insure their viability in today's climate. The greater visibility of defense operations in the public media is challenging time-honored tenets in precepts; the apathy of the American public to large defense expenditures is forcing a decline in military appropriations in the face of escalating costs. Thus the R&D objective of military technological superiority needs reevaluation.

An essential element of detente lies in the arms limitation talks which can be successfully sustained so long as each power considers that neither possesses a decisive military advantage over the other. Each power's estimates of the military potential of the other must include not only quantitative considerations but qualitative considerations as well. Here the Soviets have a great advantage over the Americans in that the openness of the U.S. society yields more intelligence of American military systems. The United States can only overcome this disadvantage by maintaining overall technological superiority which will permit recovery from an underestimation of the military potential of Soviet technology. Furthermore the possession of overall military technological superiority by the United States will permit its representatives to negotiate with those from the USSR from a position of strength. No other objective of defense R&D than that of technological superiority of military forces is viable now or in the foreseeable future.

Because of limitations in the available resources it is impossible for the United States to maintain technological superiority in all areas of technology of military significance. A broad-based research program, available to the DOD in government laboratories, industry and nongovernmental institutions, is essential to provide the United States a basis for estimating military application of new scientific discoveries and determining those which offer significant potential. An advanced technological base in all areas of significant military potential is necessary to reduce

the possibility of a military technological surprise and to rapidly overcome technological advantages held by the USSR.

In the face of declining defense appropriations, DOD planners should seek ways to more effectively capitalize on the American consumer economy. To accomplish this the DOD should undertake programs to minimize the classification of military technology, to increase the industrial awareness of military needs, to reduce the stringent specifications imposed on military equipment, to use industry more freely in military logistics and other similar programs, and to more closely couple American military technology to the civilian consumer industry.

TECHNOLOGICAL SUPERIORITY VERSUS TECHNOLOGICAL BALANCE

by

W. Perry

TECHNOLOGICAL SUPERIORITY VERSUS TECHNOLOGICAL BALANCE

SUMMARY

U.S. maintenance of technological superiority over the Soviet military has been an implicit objective of the United States for many years. Recently, however, as economic and political pressures call for a more precise defense planning, it has become clear that the concept of technological superiority needs to be defined more carefully than in the past. For example, how do we measure technological superiority? In what areas do we need it?

An alternative concept--that of technological balance--is now under consideration. This concept implies that we are in a technology race which is a dynamic process, but it would also allow an opportunity for self-restraint on the part of both countries. Each side would attempt to neutralize any advantage which the other gained. The question is, can the security interests of the United States be protected under such a planning rationale?

Four basic reasons underlie the concept of technological superiority:

- To overcome the intelligence imbalance. The Soviets know in advance what we are planning, but we know what they are planning only after they have carried out their plans.
- To prevent intimidating technological surprises. A superior scientific and technological base can give us a better chance of hedging against unexpected breakthroughs which could upset the balance of power.
- To compensate for general purpose force imbalances. Greater weapon effectiveness is needed to offset our quantitative inferiority.
- To provide bargaining incentives in arms control negotiations. This would involve the actual demonstration of new weapon performance, the effect of which might be to slow the arms race rather than increase it.

Superiority in weapon performance, however, is not the measure of merit we are interested in. It is the combined performance of many weapons that determines our ultimate objective--superiority in force effectiveness. This might be achieved through a selective superiority in certain weapons and parity or even inferiority in others. This concept leads to the technological balance rationale, which has considerable merit in the interest of economy. This is a strategy of response with a net bias in our favor.

A basic ingredient, however, is necessary to maintain a technological balance. This is technological base superiority. This base is composed of two parts, only one of which involves the defense R&D effort. The other part is the general national technology base composed of all scientific and technological activities and expertise in the nation (excluding the defense R&D), which receives three or four times the amount of annual expenditures going to the defense base. Currently the United States enjoys a clear superiority over the Soviet Union in this regard, and there seems little danger of our being overtaken as long as we maintain a stronger economy than the USSR.

This superior technological base would enable us to pursue an R&D rationale of general technological balance and selective technological superiority. Thus we would not modernize our forces unless in response to Soviet moves; at the same time we would have technological superiority in critical weapons systems so that the net force effectiveness would be in our favor at all times.

Under such a concept the role of defense R&D would be twofold: it would maintain a defense technological base which would study the potential of technology for enhancing weapon and force effectiveness, and it would also develop the technological hedges needed to maintain an overall force effectiveness in response to Soviet moves.

In order to accomplish this dual role, the defense R&D effort must draw heavily from the nondefense technological base. Thus there is an immediate and urgent need for careful long-range defense planning integrated with total resource utilization.

TECHNOLOGICAL SUPERIORITY VERSUS TECHNOLOGICAL BALANCE

A. Purpose

The purpose of this paper is to examine the R&D planning guidelines of technological superiority and technological balance to determine which is the more appropriate in today's political, economic and military environment.

B. Background

The maintenance of technological superiority of the U.S. military over the USSR has been an implicit objective of the United States for many years. During the last decade, as the technology gap has been narrowed, the maintenance of technological superiority has become an explicit rationale for the U.S. R&D program.[1] However, as recent economic and political pressures call for more precise defense planning, it has become clear that the concept of technological superiority needs to be defined more carefully and applied with a greater degree of discretion than in the past. Many questions need to be addressed such as, is technological superiority necessary or crucial for the protection of U.S. interests? In what areas is it necessary? How much superiority do we need? How do we measure it?

In the interests of slowing or halting the arms race between the United States and the USSR, the concept of technological balance is under consideration as an alternative to technological superiority. In this concept, each side acts to equalize itself, technology-wise, to the state of the other side, or to neutralize any advantage that the adversary might temporarily have. This implies that no permanent state of inequality or inferiority will be tolerated by either side and that we are in a technology race which is a dynamic process,

---

1 See Statements to Congress by the last three Secretaries of Defense and by the last two Directors of Defense Research and Engineering.

where the time constants (lead or lag times) rather than the technology differences may be the important factors.

The value of the technology balance rationale is that we would not be constantly pressuring ourselves, and indirectly the Soviets, to improve the quality of forces. It would allow the opportunity for self-restraint on the part of both the United States and the USSR to stretch out the force modernization process. The question is, can the security interests of the United States be maintained under such an R&D planning rationale? Is there not too great a danger of technological surprise which would seriously weaken our force effectiveness?

C. Statement of the Problem

It is well recognized that in spite of our present objective of technological superiority there are a number of areas in which U.S. military technology is equal to or even inferior to that of the Soviets. Consequently, it is clear that we are presently in a state of partial technological superiority and partial technological balance. The problem is to bring this currently practiced but unofficial rationale of partial superiority and partial balance into better focus so that we can be more precise and effective in our R&D planning.

Specifically, we need to define what we mean by technological superiority and where, why, and how much is needed to protect U.S. interests. Likewise, we need to define what technological balance means and where and how it can be practiced without endangering U.S. security interests. Finally, we need to show the value and the general methodology for a composite, integrated R&D planning rationale involving both the concepts of technological superiority and balance.

D. Discussion

To determine what is meant by technological superiority we must first determine what we are trying to accomplish with technological superiority.

There are perhaps four reasons for technological superiority. The first and most commonly stated reason is that it is needed to overcome the intelligence advantage held by the Soviets. It is argued that since Soviet visibility is much greater than ours, we cannot rely on a purely responsive weapon modernization program. If we did, then we would find ourselves continually behind the Soviets in force effectiveness, since they know in advance where and how to improve their weapons, while we know only after we see what they have done. In this case technological superiority means two things: (1) superiority in weapon performance on a side-by-side and face-to-face basis to ensure that our weapons will not become greatly inferior to the Soviets' if they are in the process of improving theirs and (2) superiority in understanding the potential of weapon technology so we can anticipate the improvements the Soviets can make and know what we must do to counter these potential improvements.

A second reason for technological superiority is to prevent intimidating technological surprises. Technological superiority is needed (1) to provide an early understanding of the potential breakthroughs and innovations that are possible in weapon technology and (2) to develop a capability for responding quickly to threatening Soviet technological developments. This reason is closely related to the first, but differs in that intelligence imbalance is not a significant factor. Rather, the concern is unpredictable, unexpected weapon innovations that can upset the balance of power. The emphasis is on surprise and technological breakthrough. The fact that the Soviets know more about our forces than we about theirs is immaterial. In this case technological superiority does not mean superior weapon performance. Rather it means a superior science and technology base (1) to give us a better chance of discovering and determining the potential of technological breakthroughs and (2) to provide us with the capability to develop hedges against potential breakthroughs.

A third reason for technological superiority is to compensate for general purpose force imbalances. In this case we need much greater unit effectiveness than the Soviets to make our outnumbered forward forces and our CONUS-based support forces into credible deterrents. It is clear that this reason for

technological superiority means superiority in weapon effectiveness on a face-to-face basis to provide exchange ratios much greater than unity.

The fourth reason for technological superiority is to provide bargaining incentive in arms control negotiations. By demonstrating to the Soviets, through advanced or engineering developments, that we can incorporate new weapon technologies, capable of upsetting the balance of power, we may have a bargaining chip to trade with the USSR for a cutback of its forces or developments. By so bargaining, technological superiority would be a means of slowing the arms race rather than increasing it, as is commonly argued. Here, technological superiority means superiority in demonstratable weapon performance (in the advanced development or engineering development stage). It is the reverse of the technological surprise case, where we, rather than the Soviets, disclose a weapon innovation that can place the Soviets at a severe disadvantage.

Recapping, we find there are four reasons for technological superiority over the Soviets: (1) to overcome the intelligence imbalance, (2) to prevent technological surprise, (3) to compensate for force imbalances and (4) to provide bargaining chips. On the basis of these reasons, technological superiority can be interpreted as basically two types of superiority: (a) superiority in weapon performance and effectiveness on both a side-by-side comparison and a face-to-face confrontation and (b) superiority in technological base. The superiority in weapon performance is needed to overcome intelligence and force imbalances, and the superiority in technological base is needed to provide the superior understanding required to prevent technological surprises and to develop bargaining chips.

Let's examine in greater detail the superior weapon performance aspect of technological superiority. Here we are concerned with compensating for U.S. inferiority in intelligence and in force size. With regard to the latter, the meaning of technological superiority is quite clear. Our national goal involves deterring or containing armed aggression in all parts of the globe, hence we need highly transportable and mobile forces. Because of

logistics problems we want highly accurate and efficient weapons which will minimize the number of weapons needed along with their logistic support requirements. Thus we want superior weapon technologies that will provide us with higher exchange ratios and lower logistic requirements than the adversary. Without such a technological superiority it is doubtful that the United States can maintain a credible deterrent against regional armed aggression in remote parts of the world.

The nature of the technological superiority required to overcome the U.S. intelligence gap is not as clear as above. In this case we are concerned with being inferior to the Soviets due to either underestimating their weapon performance or not seeing a weapon development until it is too late for us to respond. To avoid long periods in which our weapons could be inferior to Soviet weapons we must continually strive to deploy weapons that are of superior performance to Soviet deployed weapons. If we are fearful of the consequences of weapon performance inferiority, every time the USSR upgrades a weapon, we must upgrade ours to stay a step ahead. In this case, superior weapon performance could mean superior weapon characteristics on a side-by-side basis (e.g., missile velocity or accuracy), where the characteristics are critical to weapon effectiveness. Or it could mean superior overall weapon effectiveness on a side-by-side or face-to-face basis, such as tank compared to tank or tank against tank.

There are two considerations which make this type of rationale questionable. In the first place, it is not economically or physically possible to maintain superiority with all weapons. Secondly, weapon performance is not the measure of merit we are ultimately interested in. It is the combined performance of many weapons which determines our ultimate objective--superiority in force effectiveness. It is possible to be inferior in many weapons and still maintain an unquestionable superiority in force effectiveness, if we have the proper selection of weapons in which we have superior performance. Thus, the technological superiority required is selective and it is not necessary to maintain technological superiority on all weapons. This in effect argues against technological superiority of deployed forces on a face-to-face or side-by-side basis, as a valid rationale to offset

intelligence imbalance. The true rationale is superiority in force effectiveness which translates into a rationale of technological superiority for selected weapons and technological parity or inferiority for the remaining weapons.

As an example of this rationale, consider land combat forces consisting of armor with air support. It is not necessary that the armor and aircraft be of superior performance as long as we have a clear superiority in target acquisition capability and in air-to-air, air-to-ground and ground-to-air weapon capability.

This now leads to the rationale of technological balance for weapon systems under development and deployed. The rationale is based on the fact that we can have an effective deterrent and containment capability even if a significant fraction of our weapons are inferior to the Soviets. Put in another way, for many of our weapons, our force modernization process can lag behind the Soviets without endangering our security interests. We offset this technological inferiority in some weapons with technological superiority in others to achieve an overall superiority in force effectiveness.

In the interests of economy and arms control, the technological balance concept has considerable merit and would work as follows. At any point in time the U.S. force planners would make an assessment of Soviet and U.S. capabilities and determine where superior weapon performance is required and inferior weapon performance can be tolerated to maintain security interests (superiority in force effectiveness) in the face of an intelligence imbalance. This would define the weapon developments that must proceed and those that can be postponed. When any significant change in Soviet developments or force posture takes place a reevaluation is made to determine whether the United States can best counter this move with increased or new procurements or perhaps with a new technological development. The concept is, in effect, one of a technological balance with a net bias in our favor. The aspect of a balance comes from the fact that it is a strategy of response, not of continual self-imposed modernization to attempt to widen the

technological gap or improve our technological position. Rather, it attempts to maintain a fixed technological gap which is necessary to overcome only the intelligence gap. The significance of this is that we do not take advantage of technological opportunities and develop new or improved weapons until necessary (1) to counter Soviet moves or (2) to replace aged systems. With such a restraint in weapon development and deployment the U.S. contribution to the arms race would be reduced with corresponding reductions in defense expenditures. This would provide the USSR the opportunity for restraining its weapon developments and deployments and possibly result in self-imposed bilateral reductions in the arms race.

The basic ingredient necessary to maintain a technological balance biased in our favor is technological base superiority. This also is the requirement for preventing technological surprise and for creating technological opportunities that can be used as bargaining chips. The U.S. technological base is composed of two parts, each equally important in the attainment of U.S. military technological objectives: (1) the general national technology base comprised of all scientific and technological activities and expertise in the nation excluding defense R&D and (2) the defense R&D effort. In terms of yearly expenditures the effort going into improving the national technological base is thre or four times the defense R&D effort. Thus it is clear that the nondefense effort is largely responsible for the progress made in the fundamental sciences and technologies such as electronics, data processing, and transportation. The defense contribution to the technology base consists of applying the nondefense expertise to weapon systems. In addition, the defense effort contributes to advancing the state-of-the-art for technologies which are not ordinarily pursued in nondefense work. Thus the defense technology base contribution is one of augmenting and focusing the overall technology base in defense areas.

Currently the United States enjoys a clear superiority over the Soviet Union with regard to the overall technological base. Since the progress made in the nondefense portion of the technological base is more a function

of the size and health of the U.S. economy than anything else, it would seem that there is little danger of the Soviet Union overtaking us in overall technological capability as long as we maintain a stronger economy than the USSR.

The superiority in technological base provides the U.S. defense planners with an earlier and clearer understanding of what technological opportunities are feasible and how they can be applied to enhance weapon performance. It is this earlier understanding that enables the United States to maintain superiority in force effectiveness with a responsive defense R&D rationale. The superior technological base allows us to estimate with confidence how far the Soviets can progress during any modernization cycle. Thus, even with inferior intelligence we can anticipate possible Soviet moves and make sure we have sufficient hedges to insure force superiority under all reasonable circumstances.

In this manner a superior technological base enables us to pursue an R&D rationale of general technological balance and selective technological superiority. The general technological balance implies that we would not modernize our forces unless we are forced to by Soviet moves--i.e., we would respond rather than initiate--and the selected technological superiority means that we would maintain technological superiority in critical weapon systems so that the net force effectiveness would be in our favor at all times.

The role of defense R&D would be twofold: First, it would be to maintain a defense technological base which provides the proper lead in understanding of the potential of technology for enhancing weapon and force effectiveness. Second, it would develop those technological hedges needed to maintain overall force effectiveness in response to Soviet moves. In both cases, to succeed, the defense R&D effort must draw heavily from the nondefense technological base. Hence the key to the R&D strategy of general technological balance and selected technological superiority is careful and integrated long-range defense planning with total resource utilization.

E. Summary of Major Findings

There are four reasons for maintaining technological superiority over the Soviets: (1) to compensate for the U.S. intelligence disadvantage, (2) to prevent technological surprise, (3) to compensate for force size imbalances and (4) to provide bargaining incentives. On the basis of these four reasons, technological superiority can be interpreted to mean two things: (a) superiority in weapon performance and effectiveness on a side-by-side and face-to-face basis to compensate for intelligence and force size disadvantages and (b) superiority in technological base to provide the understanding needed to avoid technological surprises and prepare bargining chips.

It should not be necessary to maintain an across-the-board superiority in weapon performance to compensate for intelligence and force size disadvantages In the interest of minimizing defense costs, the United States should be willing to accept inferiority in some weapons as long as the effectiveness of its combined weapons (i.e., forces) is superior to the Soviets. Furthermore, in the interest of slowing the arms race, it is desirable that the United States should not initiate weapon modernization unless forced to by Soviet moves or by weapon aging.

To accomplish this, the United States can adopt a defense strategy of general technological balance with selected technological superiority. In this concept the United States would be primarily concerned with maintaining a weapon posture which provides sufficient superiority in force effectiveness to offset intelligence and force size inferiorities. To achieve superior force effectiveness for minimum cost certain critical weapons would require superior performance, while others could be equal or inferior to the Soviets to provide a net effectiveness in our favor. With a force effectiveness advantage the United States can afford to adopt a responsive force modernization strategy, whereby technological opportunities are developed or incorporated into the force only as a response to Soviet moves (i.e., to maintain a net technology gap in our favor) or in the replacement of aged weapon systems.

The essential ingredient for the success of such a strategy is the maintenance of a superior technological base. With the superior technological base comes the understanding and technological opportunities necessary to estimate the limits of Soviet advances and to prepare for Soviet advances by appropriate weapon developments. Thus a superior technological base allows the United States to lead Soviet technology in such a way that we can adopt a responsive weapon development and deployment strategy without fear of being inferior from an overall force effectiveness standpoint.

Technological understanding and opportunities in defense are products of the overall U.S. technological base including nondefense as well as defense science and technology. Currently the United States holds a substantial lead in total technological capability and will most likely retain this lead as long as the U.S. economy is substantially stronger than the Soviets'. Hence a strong technologically oriented economy provides the United States with the wherewithal to move more towards a responsive defense strategy conducive to reducing costs and arms.

In addition to providing the understanding necessary to offset intelligence and force size imbalances, a technological base superiority is necessary to prevent technological surprises. In this case we are concerned with surprising Soviet technological breakthroughs that can seriously diminish the effectiveness of our forces. Since the exploitation of a technological innovation requires the integration of many different technologies, a diverse and superior technological base allows the United States to identify the areas in which damaging technological surprises are possible and take steps to hedge against surprising Soviet breakthroughs. Thus, for critical weapon systems such as our strategic deterrents, we need to study all imaginable ways the Soviets could defeat the weapon systems, and develop hedges against those ways that are within the realm of possibility. Here, the U.S. lead in most technologies enables the United States to identify potential system weaknesses before the Soviets can exploit them with technological innovations.

We see that a technological base superiority is the key to adopting a defense strategy that is appropriate to today's economic and political objectives. A key role of the defense R&D program is to utilize to the maximum extent possible the general U.S. technological base in order to provide the technological understanding and opportunities necessary to anticipate and counter Soviet advances or technological surprises. It is the job of the defense R&D effort to continually identify and investigate any and all technological opportunities with potential application to weaponry and to pursue those that are most promising for enhancing force effectiveness or for countering potential technological surprises. In this way, a satisfactory menu of options can be maintained in appropriate states of development, ready to respond to Soviet moves.

TECHNOLOGICAL SURPRISE AND DEFENSE R&D PLANNING

by

W. Perry

TECHNOLOGICAL SURPRISE AND DEFENSE R&D PLANNING

SUMMARY

Technological surprise can be grouped into three categories: (1) tactical, such as the Nazi blitzkrieg of World War II; (2) engineering, such as Big bertha and the armored tank of World War I; and (3) scientific, the only example of which to date is the atomic bomb. The relative lack of scientific surprise is due to the free exchange of information in the scientific community, the scarcity of scientific innovations having a potentially great impact, and the time required to implement the discovery by providing the necessary engineering developments. A review of past technological surprises reveals that every one of them could have been prevented with better planning.

To determine the feasibility of technological surprise today, it is necessary to establish what kind of technical innovations could severely weaken our defenses. With regard to the U.S. strategic deterrent forces, the Soviets could render them ineffective by (1) destroying the deterrent weapons before they are launched (first strike); (2) destroying the warheads in flight (ballistic missile defense--BMD); or (3) a combination of first strike and BMD.

In the case of first strike against the U.S. submarine deterrent, the threat of most concern would be a breakthrough in underwater detection and tracking in combination with ship-based or land-based missiles. Other possibilities include exotic mines that could be placed surreptitiously on the submarine for later detonation and coordinated sabotage of food or atmosphere. The most serious first-strike threat against the Minute Man would be a breakthrough in terminally guided ballistic missiles. Another possibility would be the discovery of a device of such overwhelming

power that an efficient first strike could be achieved without the requirement for improved accuracy. Of the three deterrent forces, the bomber force is the least vulnerable to first strike.

Ballistic missile defense against ICBMs and SLBMs is another matter. With current BMD technology, the cost of defending against U.S. ballistic missile forces would be exorbitant, and even then confidence in being able to keep leakage to acceptable levels would be very low. Thus significant technological breakthroughs would be required before an effective Soviet BMD system could be seriously considered. For terminal or midcourse BMD, breakthroughs would be required to give high confidence of acquiring, discriminating, and tracking reentry vehicles in a penaid and cluttered environment. A particularly fearful innovation would be some type of remote technique for prefuzing the reentry vehicle warhead as soon as it is armed. Other developments might include (1) a boost tracking system capable of determining the precise specifications of reentry vehicle trajectories, thereby enabling intercept by a mid-course or near-terminal missile without the need for acquisition, discrimination, or tracking, and (2) satellite-based laser or particle guns to destroy missiles during boost.

Could the United States be surprised by these innovations in such a way that an effective response would not be possible until too late? The only realistic way that the United States could incur a scientific surprise would be from indecisive or short-sighted defense planning on the part of the United States, and not from a surprise discovery or a surprise application by the Soviets. To avoid this outcome, the United States must (1) maintain an adequate scientific and technological base, (2) understand the potential of science and technology, (3) understand the needs of technology, and (4) develop required technologies. This can be achieved by improving the dialogue between the creative weapons system analyst and the scientist or technologist, by broadening the scope of industry participation in the defense effort, and by establishing a separate DOD agency to coordinate and integrate all activities for determining technology needs for avoiding technological surprise.

TECHNOLOGICAL SURPRISE AND DEFENSE R&D PLANNING

A. Purpose

The purpose of this paper is to examine technological surprise as a threat to national security and to evaluate its role in defense R&D planning.

B. Background

The notion that the Soviets might achieve, unsuspected, a technological breakthrough that could threaten U.S. security interests has been a concern to the U.S. defense establishment since World War II. In fact, it was just such an achievement, namely Sputnik I, that gave cause for the creation of the Advanced Research Projects Agency in 1958, whose mission was to prevent further such technological surprises.

The answer to technological surprise as well as the answer to any weakness in strategic and general purpose forces has been the maintenance of technological superiority. The defense R&D effort has concentrated on establishing an across-the-board technological superiority to provide for all imaginable contingencies, and the threat of technological surprise has been to a large extent obscured by an impressive show of technological muscle.

Recent events, however, have refocused attention on technological surprise as a rationale for R&D programs. The reordering of national priorities with the attendant reduction in the defense effort has threatened the capability of the United States to maintain an overpowering technological superiority except possibly in crucial areas. This means we must be highly selective in our R&D programming. In guarding against technological surprise we must concentrate on those areas in which an innovation can seriously

jeopardize national security. Thus there is a need to be more precise in our understanding of how technological surprises can hurt us and of how best we can prevent their occurrence.

To put it in another way, we can no longer afford to take for granted the requirement for technological superiority. We must address ourselves to why we need technological superiority, where we need it, and how much we need. These answers lie in a better understanding of our susceptibility to technological surprise and what we must do to prevent it.

Stabilization of strategic nuclear forces per the SALT agreements has also given new perspective to the threat of technological surprise. Prior to acceptance of strategic nuclear parity as a desirable state, U.S. dominance in both the quantity and quality of strategic deterrent forces gave little cause for concern over technological surprises. We have agreed to a strategic balance because we can see no way in which the Soviets could render our deterrent force ineffective now or in the foreseeable future. However, for all practical purposes we must view an effective strategic deterrent as a permanent requirement, for tens, hundreds, and possibly thousands of years to come. Hence the possibility is very real that new technologies will be developed in the future which can neutralize present-day strategic deterrent forces. Our principal concern, then, is to settle down with an affordable long-range R&D program that will provide the necessary assurance that when and if technological breakthroughs occur, we will not be surprised and will be in a position to maintain national security. Thus the stabilization of strategic forces draws attention to the fact that prevention of technological surprise is truly a long-range (as well as a short-range) requirement and we should plan accordingly.

One final statement about the potential seriousness of the technological surprise threat. It cannot be disputed that our national security depends to a large degree on the maintenance of a balance of power. With responsive defense planning and responsible congressional action it can be argued that the only way that a damaging imbalance of power can occur, to

our detriment, is through technological surprise. To put it more directly, with rational planning and decisionmaking, the only rational way our strategic deterrent can fail is if the adversary finds a technological breakthrough which can render our weapons ineffective and which can be developed unbeknownst to us. Consequently, guarding against technological surprise is possibly the most important problem the defense establishment is faced with.

C. Statement of the Problem

It is clear that an essential role for defense R&D is to prevent technological surprises which are a threat to national security. What is not clear is how to go about insuring against technological surprise with a minimum of effort. This is a key problem defense R&D planners are faced with today and it is the basic problem addressed in this paper.

There are two aspects or phases to the investigation of this problem. The first is to explore fully the nature and feasibility of damaging technological surprises, i.e., to identify the mission and technology areas within which technological breakthroughs could seriously damage national security, and to determine the circumstances under which these breakthroughs could occur undetected or unrecognized by the United States. Of interest here is the technological sophistication and awareness of the United States and the part this would play in alerting the defense planners to potential dangerous technological breakthroughs.

The second phase of the problem is to explore means of preventing damaging technological surprises through proper R&D planning. This will include means of detecting and recognizing potential threatening breakthroughs as well as means for responding to insure that the United States would not be put into a disadvantageous position if the breakthrough indeed developed. The part that a broad technology base plays in preventing technological surprises is of particular interest.

D. The Nature and Feasibility of Technological Surprise

The threat of technological surprise is the threat of an upset in the balance of power in a manner which precludes our timely response. There are two essential elements to the threatening technological surprise--the element of overpowering effectiveness, requiring that the technological breakthrough have the potential for creating an unstable imbalance of power; and the element of surprise, requiring that the technological development be undetected or unrecognized until a sufficient leadtime has accrued to deny the development of an adequate counterweapon. If a technology breakthrough lacks either of these key elements--overpowering effectiveness or sufficient surprise--then, for the purposes of this paper, it is not considered a threatening technological surprise. The reason for this is that normal technological improvements, lacking either the surprise element or the intimidating effectiveness, can be adequately countered by normal R&D planning methods. What we are concerned with here are the unusual and unsuspected innovations, i.e., the technological revolutions rather than evolutions, which place unusual and difficult demands on our R&D effort to prevent their occurrence.

It is emphasized that undetected technological developments which represent only a modest improvement in weapon performance and do not have a significant impact on the balance of power do not qualify as threatening technological surprises. Surprise developments may result in a loss in U.S. prestige or a temporary reduction in military force effectiveness, but as long as they do not provide the adversary with an impelling effectiveness advantage it cannot be considered a threat that must be vigorously guarded against.

The reason for this is that our nuclear deterrent forces, both strategic and tactical, are so excessive and devastating that the adversary cannot use modest improvements in force effectiveness to his benefit without unreasonable risk. Thus, if the Soviets should spring a surprise on us of, say, a tactical aircraft which surpasses the performance of any of our

aircraft, then we would in the normal course of R&D planning, study the problem to determine if we need to improve our weapons and, if so, we would then go about developing the necessary improvements. Although we might be at somewhat of a disadvantage during this period of catchup, the effect on the overall balance of forces and on U.S. national security would be negligible. When considered in the context of our total destructive capability, the Soviets would find their momentary advantage useless.

There is another consideration which eliminates from the defense R&D planning function the job of guarding against undramatic technological surprises. This is the recognition that there is no feasible and affordable way to prevent all technological surprises. To do so we would require an unlimited budget as well as unreal clairvoyance. Thus, with a severely constrained defense budget, it makes no sense to attempt to guard against being surprised by modest technological improvements. In the interest of national security we have much better uses for the money, namely, guarding against damaging technological surprises, identifying useful technological opportunities, and providing recognized weapon improvements based on clearly defined needs.

1. Technological Surprise in the Past

Now that the essential characteristics of threatening technological surprises have been set forth let us examine those developments of the past which qualify as technological surprises to see if we can develop a basis for why and how technological surprises do or do not occur. If technology is considered in the broadest sense, to include application of technological systems, then all technological surprises can be grouped into three categories: tactical, engineering, and scientific. Tactical surprises consist of new and innovative applications or deployments of existing technological systems (i.e., weapons). Engineering surprises consist of new or greatly improved technologies. Scientific surprises consist of new weapons and technologies derived from new scientific principles.

A good example of a tactical surprise that had great impact was the Nazi blitzkrieg at the start of World War II. This was clearly a surprising and innovative deployment and tactical integration of three existing weapon systems (i.e., aircraft, tank, and infantrymen), and France, Poland and England did not have time to redistribute, redeploy and retrain their resources before Western Europe was overrun.

Two examples of engineering surprises are the developments of Big Bertha and the armored tank during World War I. In the case of Big Bertha, a 16.5 inch howitzer, it was secretly developed by Germany to destroy the Belgium forts that had been constructed to withstand the 9 inch howitzer. Big Bertha took the Belgians by complete surprise at the start of the war and naturally did what the Germans intended it to do. Both this incident and the blitzkrieg example serve to point out the advantage that the premeditated attacker has in developing technological surprises. He has the advantage of time and information for deciding how to gain the upper hand and for developing the required technology.

The armored tank is an interesting example of an engineering surprise that developed during World War I. It was conceived at the onset of the trench warfare by a British colonel who saw that by putting armor and guns on the caterpillar tractor he would have an answer to the machinegun. Although it was slow in developing (cavalry officers had a difficult time resisting their love for horses), the Germans were "surprised" by it in the sense that they didn't recognize its potential until too late. The allies produced thousands of tanks, while only 45 German tanks ever saw action. Consequently, when the tank proved its worth in the last battles of the war, the Germans recognized that the balance of power had clearly shifted in favor of the allies and quickly agreed to an armistice.

Although the history of weapons is full of examples of engineering innovations having the potential for upsetting the balance of power,[1]

[1] For example: the breechloader, the rifle, the machinegun, the submarine, the exploding shell, the bomber.

in very few instances did the technology develop rapidly enough to clearly benefit one side. Generally when the concept was first conceived and implemented the technology was so crude it did not have significant impact on weapon or force effectiveness. Both the conservatism of the user[1] and the lack of confidence or foresight of the decisionmaker[2] helped to retard the development of weapon innovations so that they lacked the elements of surprise and effectiveness. In most instances the development was so slow as to allow both sides to maintain a rough balance of weapon and counter-weapon developments. In general, wars or battles have been lost, not because of technological surprises but because of lack of resources, poor planning, or poor tactics.

It is probably significant that since the beginning of the industrial revolution only one scientific innovation developed rapidly enough and possessed sufficient effectiveness to be clearly classified as a scientific surprise. This was the atomic bomb. Although there is considerable debate over what it actually accomplished when first introduced, there is no question that the awesome effectiveness and the speed of development of the atomic bomb provided it with the potential for completely upsetting the balance of power at the time.

Two other scientific innovations in World War II helped restore the balance of power to the allies in the early stages of the conflict. The radar helped England win the battle of Britain and VT fuze helped the United States gain the upper hand in the Pacific. However, it is not clear that these systems were sufficiently effective and surprising when introduced to significantly alter the course of the war.

---

[1] The breechloader was introduced in the British army during the American Revolution. It is entirely possible it could have changed the course of the war, but the British regulars were unwilling to shift allegiance from the beloved Brown Bess.

[2] Machiavelli in his Art of War in 1521 suggested that war should return to tactics and weapons used by the Roman legions. He thought firearms were inefficient and could see no future for them. At that time guns had been in use for 150 years.

Prior to World War II, scientific surprises just did not occur. There are at least two basic reasons for the scarcity of scientific surprises. First, scientific discoveries are generally a product of research by scientists unconcerned with weapon applications. They are strongly inclined to publicize their discoveries as soon as possible; thus the surprise element quickly disappears. Such is the case with the rather recent laser discovery and even in the case of the atomic bomb, the basic principle of the fission chain reaction and its potential for releasing great amounts of energy had been published in scientific literature before the United States began its development.

Second, there have been very few scientific discoveries which by themselves led directly to greatly improved or new weapon systems. Generally a scientific discovery will provide for only a marginal improvement in a weapon system and will not have a dramatic impact on effectiveness. Furthermore, scientific innovations require a great deal of engineering development before the full potential of the discovery can be realized. This engineering development usually takes years or even decades. Thus the majority of scientific innovations provide for evolutionary weapon development, rather than revolutionary as is required for a threatening technological surprise. Such is the case of the aircraft and guided missile which evolved through many small scientific advances and a great deal of engineering developments in many fields.

We can conclude from this review of military history that damaging technological surprises have indeed occurred in the past, although not frequently. By far the most important has been the technological surprise which grew out of a scientific discovery, i.e., the atomic bomb. Yet these so-called scientific surprises have been very rare due to the free information exchange in the scientific community, to the scarcity of scientific innovations having a potentially great impact and to the time required to implement the discovery by providing the necessary engineering developments.

There have been a good many more engineering surprises but these have in general lacked great impact. Tactical surprise, i.e., innovations based on the technology of tactics and deployment, have been most frequent but in most cases they affected only the outcome of a battle and did not permanently alter the balance of power.

A key finding obtained from the review of historical technological surprises is that nearly all major technological surprises which have occurred could have been prevented with better planning--that is, almost no surprises occurred due to the lack of scientific or engineering information on the part of the surprised party. Each side started with the basic understanding of the technology potential but, due to poor planning and visibility, one side chose not to pursue or guard against the idea and ended up in an inferior position. This was the case with the armored tank in World War I and the radar in World War II. Germany had sufficient information on both of these inventions to react in time but didn't recognize the potential until too late. In fact, it was Hitler who stopped the radar research for two years, until he discovered the British were winning the battle of Britain with it. Even in the case of the atomic bomb, German scientists knew of the fission chain reaction feasibility and in all probability had considered the possibility of an atomic bomb. But Hitler's lack of interest in scientists[1] precluded nuclear weapon development by Germany.

This is not to say that all future technological surprises can be prevented by good planning. Rather, the fact that all major technological surprises in the past could have been prevented by good planning gives us incentive for good planning in the future and the encouragement that, if we achieve it, historical precedent is on the side of our not being technologically surprised.

---

[1] Hitler was planning for a short war and didn't believe any scientific discovery would be developed in time or be needed.

2. Technological Threats to the Balance of Power

We've been able to identify technological surprises of the past, the most impressive of which was the atomic bomb development. How about their occurrence in the future? Armed with nuclear weapons by the thousands, delivery systems of all types, and a sophisticated and responsive technological community, is it possible that we can be placed in a severely weakened military position by a technological invention which we are unaware of or do not recognize until too late? After all, since the atomic bomb, no technological surprises have occurred which seriously impact on the balance of power and this has been a period of great scientific endeavor and achievement on both sides. Sputnik I was a surprise which damaged our ego but otherwise did no appreciable damage. In fact, it probably had the opposite effect by providing a great deal more incentive to our space and defense programs. The Soviets tried a tactical surprise by secretly deploying IRBMs in Cuba, but we had little trouble countering that move with good intelligence backed by overpowering general purpose forces. The fractional orbital bomb (FOBS) was a surprise innovation that had escaped our weapon system designers (for good reason, as it turned out). Although it gave us some anxious moments when it was first observed, the period of development and test provided us with plenty of time to develop a counterweapon if needed. Actually, other defense moves we had made for other reasons rendered the FOBS a weapon of little concern to us. Perhaps the development that surprised us the most was the speed with which the Soviets produced first the atomic, then the hydrogen bomb. Although this had no unsuspected impact on the balance of power, since we knew they would be able to develop the weapons eventually, it did cause us to speed up our defense effort.

In exploring the feasibility of technological surprise today, let's first determine what kind of technological innovations would be needed to severely weaken our defenses. With regard to our strategic deterrent forces, there are three ways the Soviets could render them ineffective: (1) by destroying our deterrent weapons before they are launched, i.e., first strike, (2) by destroying our warheads in flight, i.e., air defense and ballistic missile defense (BMD), and (3) by a combination of first

strike and defense. What we want to determine is where technological breakthroughs could occur in these areas which could give the Soviets confidence that they can neutralize all three legs of the U.S. deterrent Triad.

In the case of first strike against our submarine deterrent, two or three possibilities come to mind. The threat of most concern would be a breakthrough in underwater detection and tracking, in combination with ship-based or land-based ASW missiles. Another possibility might be exotic mines which can be surreptitiously attached to the submarine in leaving the harbor and activated at a later time. Since there are a relatively small number of submarines, the possibility exists for a breakthrough in coordinated sabotage, e.g., coordinated poisoning of the food or atmosphere at a prescribed time.

In the case of first strike against Minuteman, a recognized threat is a highly accurate counterforce attack in combination with pindown. It is generally believed that the accuracy required with either ICBM or SLBM forces cannot be obtained, with confidence, without some sort of terminal guidance. Hence a breakthrough in terminally guided ballistic missiles is the innovation of most concern. Another possibility is the scientific discovery of a new device which would be of an order of magnitude more powerful than present nuclear weapons. This would enable an efficient first strike without an improved accuracy requirement.

It is rather ironic that our bomber force, which is the oldest leg of the Triad, is probably the least susceptible to first strike. Even with depressed trajectory SLBMs, the Soviets cannot prevent a considerable fraction of our bombers from being launched. This is particularly true when we consider that the forces will go on airborne alert status at the first signs of any first strike capability or intent. Perhaps the only way the bombers can all be destroyed on the ground is with an undetected SLBM attack. This requires a breakthrough in radar cross section reduction techniques.

The real threat to bombers lies in air defense. Of the three deterrent systems, bombers are easily the most susceptible to destruction after launch. Technology already exists for countering a bomber attack and it's mostly a matter of developing and deploying sufficient forces. Advanced penetration aids are in development (e.g., bomber launched cruise missile); however, even then, destroying the effectiveness of the bomber attack is not so much a matter of technological breakthrough as it is the cost of developing the needed but recognized improvements and procuring and deploying the necessary forces.

Ballistic missile defense against ICBMs and SLBMs is another matter. With current BMD technology, the cost of defending against our ballistic missile forces would be exorbitant and even then confidence in being able to keep leakage to acceptable levels would be very low. Thus significant technological breakthroughs are required before an effective BMD system can be seriously considered. For terminal or midcourse BMD, breakthroughs are required to give high confidence of acquiring, discriminating, and tracking reentry vehicles in a penaid and cluttered environment. Also a nonnuclear warhead development which provides RV lethality at much larger ranges than can be achieved with current fragmenting warheads would do much for enhancing the cost credibility of terminal as well as midcourse BMD systems. Such a development could make air defense missile upgrades effective against reentry vehicles. A particularly fearful innovation would be some type of remote technique for prefuzing the reentry vehicle WH as soon as it is armed. A longer term development would be a boost tracking system capable of the precise specification of RV trajectories, enabling intercept by a midcourse or near-terminal missile without need for acquisition, discrimination or tracking. Finally, satellite-based laser or particle guns to destroy missiles during boost is a very-long-range possibility.

Table 1 lists the developments or breakthroughs just discussed as possible means for rendering our strategic forces ineffective. The list, of course, does not include all possible methods for defeating deterrent forces. Its intent is to explore whether or not there are vulnerabilities

Table 1

TECHNOLOGICAL BREAKTHROUGHS REQUIRED TO DEFEAT U.S. STRATEGIC DETERRENT FORCES

Strategic Forces	First Strike		Defense	
	Development or Breakthrough	Surprise Potential	Development or Breakthrough	Surprise Potential
Nuclear Submarine/SLBM	• Underwater submarine detection and track	High	• Advanced acq., disc., and tracking	High
	• Exotic mines	High	• Revolutionary nonnuclear W/H	High
	• Coordinated sabotage	High	• Remote prefuzing	High
	• Counterbattery system	Low	• Boost track	Low
			• Laser/particle gun	Low
Minuteman/ICBM	• RV terminal guidance	Low	• Advanced acq., disc., and tracking	High
	• Superbomb	Medium	• Revolutionary nonnuclear W/H	High
			• Remote prefuzing	High
			• Boost track	Low
			• Laser/particle gun	Low
SAC Bomber	• Depressed trajectory	Low	• (Breakthroughs not required)	Low
	• Invisible SLBM	High		

which could possibly be exploited as a technological surprise. As is seen, we can envision potential damaging technological breakthroughs either for first strike or for defense against each element of the Triad. However, for all members of the Triad to be defeated simultaneously a combination of these technology developments must occur. There is no question that the likelihood of this occurring is remote, but there is no way to conclude that it is impossible. Hence we must conclude that, against a determined foe, a finite possibility exists that he can produce a combination of new weapon developments which can defeat our present-day deterrents. Consequently, we must plan accordingly, to ensure that we are not surprised by these developments and can take proper measures to maintain the effectiveness of our deterrents.

The potential for development of the breakthroughs surreptitiously is given in Table 1 as "surprise potential." This is an assessment of the ease with which the development can be hidden. In general, developments that require elaborate systems tests have little surprise potential. However, a breakthrough that can be proven in a laboratory environment before integrating it in a system has considerable surprise potential. It is observed that many of the possible breakthroughs have high surprise potential indicating that the strategy of waiting until the adversary has tipped his hand can be dangerous. In these areas special action is required to avoid surprise.

The problem of technological surprise for general purpose forces is more difficult to analyze than for strategic deterrent forces due to the difficulty in determining the impact a new weapon development will have on the effectiveness of general purpose forces. For the purpose of this paper we will simply attempt to identify a few areas where revolutionary improvements in Soviet weaponry are likely to seriously affect the capability of our general purpose forces.

Dramatic weapon improvements that would be particularly disruptive to U.S. general purpose forces would be significant improvements in Soviet target acquisition and location capability and in infantryman's

effectiveness against aircraft and armor. Any innovation that would provide the Soviets an unquestioned advantage in tactical target acquisition, whether by land, sea, or air, would have serious impact on the capability of our general purpose forces to deter and contain armed aggression. Likewise, a breakthrough in the Soviet infantryman's capability to neutralize armor, aircraft and emplacements would result in a dangerous shift in balance of power. Here, we can visualize a scientific discovery which could give a small-caliber weapon the capability to destroy armor or aircraft.

This brief discussion of technological breakthroughs in general purpose forces only serves to point out that one can envision revolutionary weapon improvements on the part of the adversary that can severely reduce the capability of our tactical forces. Thus, in the absence of information to say that such developments are impossible, we must argue that damaging technological surprises are a possibility for general purpose forces as well as for strategic forces.

3. Feasibility of Surprise

We've seen that there are technological areas in which Soviet breakthroughs could lead to U.S. military ineffectiveness. The question addressed here is, can we be surprised by these innovations in such a way that an effective response is not possible until too late? The key point is that we are threatened by dramatic breakthroughs or improvements in the state-of-the-art, not by predictable extensions. Thus it is not at all clear that the discovery and subsequent development to the point of a necessary leadtime advantage can be hidden or undiscernible.

The world's scientific community is highly communicative. Information exchange is relatively free, even with the Soviet Union. It is the inherent nature of creative scientists to publish their works and obtain acclaim and recognition for their accomplishments. Furthermore, the great discoveries in science are generally collective efforts by competing research centers. The process is one of stimulation and response in incremental fashion until a final experiment turns on the light and makes clear a new

scientific discovery. Without the collective thinking of the leading independent scientists it is doubtful that the major scientific breakthroughs of the past could have been accomplished.

Thus it is highly unlikely that U.S. scientists would be unaware of a major scientific discovery. Breakthroughs such as new property of matter (which could lead to an underwater surveillance system) or a new nuclear reaction (which could lead to supernuclear or mininuclear bombs) would, in all probability, be known to all scientists long before the weapon developers realized the significance of the development and put it under wraps. This is not to say there wouldn't be speculation immediately regarding the military significance of the discovery. This is certainly likely. But before the speculation could be backed with sufficient data and arguments to convince the military decisionmaker, several years could pass.

The discovery of the principle of the atomic bomb is a good example of this process. After Einstein theorized the equivalence of mass and energy in 1905 there was much speculation about the tremendous amount of energy that could be released through the conversion of a small amount of matter. However, it wasn't until fission was demonstrated in 1930 by Curie, and the neutron was discovered by Chadwick in 1932, that Szilard in 1933 visualized how energy might be released through a "chain reaction." It took six more years of work by many scientists to discover how this chain reaction might take place and only then had sufficient data been collected to interest the military decisionmakers.

Although military planners are much more aware of the potential of science today than in the pre-World War II period, there still would be an appreciable timelag between the time the scientist understands the potential of his discovery and communicates to his peers and the time the military takes over. Thus, there does not appear to be any danger of significant scientific discoveries that would occur unbeknownst to U.S. scientists.

The problem then is not one of being unaware of a scientific discovery; rather, it is one of not understanding the significance of the discovery and acting accordingly. Here, there is little question that the openness and competitive nature of the U.S. defense technological community, coupled with the large number of defense analysts, gives the United States a much better chance of understanding the military significance of a discovery long before the USSR. In fact, our understanding of the long-range military potential of innovations is almost immediate, as is demonstrated by what happened to the laser. Within a year after its discovery, defense analysts were studying its potential for any and all military applications, including missile guidance and death rays.

It seems, then, there is little danger of the United States not being aware of major scientific discoveries or their application. The principal danger comes from not following up properly on high-payoff applications. Defense planners might think the concept too farfetched, or they may lose interest with the slow progress. The USSR, on the other hand, may proceed at a great pace and perfect the concept into a scientific surprise. Thus we conclude that the only realistic way the United States can incur a scientific surprise is not from a Soviet surprise discovery or from a Soviet surprise application, but from indecisive and short-sighted defense planning on the part of the United States.

There is almost no communication between U.S. and Soviet engineering communities so the only way we can detect a technological breakthrough being engineered by the USSR is through intelligence. These engineering surprises consist of high-payoff advances in the state-of-the-art. Currently, the United States is driving hard to improve the state-of-the-art in all high impact areas of technology. Thus, we have an excellent understanding of the viability of technology extensions. With the present type of effort that continually is pushing out the frontiers of technology it is difficult to imagine how we could overlook significant technology advances--especially those advances that can destroy our military effectiveness. It would seem that there is little danger of engineering surprises.

The danger of engineering surprise is further lessened by the fact that any new or highly improved system needs the contribution of many technologies. With our lead in most technologies, it is not feasible that the Soviets, with inferior technologies, can advance one particular technology in a manner we are not aware of, and to the extent that a breakthrough in weapon system performance is achieved.

On the matter of tactical surprise, there is essentially no danger with sound operations research and contingency planning. We should be able to anticipate all threatening tactics and plan accordingly.

From this examination of our susceptibility to scientific engineering and tactical surprises, it is difficult to see how we could be surprised to our great disadvantage unless we relax our guard. Our current defense effort, supplied with the creativity and progress provided by an open and competitive industry, should preclude any damaging surprises. Any real danger appears to lie in the possibility of short sighted and indecisive planning rather than in scientific or technical capability. There is a further danger that a significant reduction in defense effort could change our present capability to anticipate and handle threatening technological innovations. The following section explores the basic R&D requirements for precluding technology surprise and postulates how threatening technological surprises can be avoided with minimum R&D effort.

E. R&D Planning for Prevention of Technological Surprise

The problem addressed here is the development of an R&D strategy which ensures the prevention of technological surprise with a minimum of effort. Or, to put it another way, the problem is to find the strategy which provides the maximum assurance against technological surprise for a given budget.

First we'll examine the specific analytical and developmental requirements for precluding technological surprise. We will then evaluate our current R&D effort for preventing technological surprise. Finally, we will suggest changes to our R&D strategy to better meet the technological surprise threat.

1. Requirements for Preventing Technological Surprise

Four types of resources or activities are required to provide assurance against technological surprise. These are listed in Table 2. The first requirement is for an adequate national scientific and technological base. This is the sum total of sc.entific and technological resources and experience throughout the United States and its allies, including academic, industrial, nondefense and defense oriented resources. The national S&T base encompasses all research, development and manufacturing technologies in all sectors of the economy.

To provide assurance against technological surprise we need a technological base superior to that of the Warsaw Pact nations. This is due to the fact that the discovery of a technological breakthrough and its subsequent development into a credible threat is the product of many seemingly unrelated technological disciplines, e.g., computers, control mechanisms, aerodynamics, electromagnetics, industrial engineering. The general level of achievement in these various disciplines determines, to a large extent, the amount of progress that can be made in any system comprised of a number of those disciplines. The full potential of an innovation or discovery in any one discipline or technology cannot be realized until other companion technologies have been sufficiently developed. Consequently, if the United States has a higher general technological base than the Soviets, their ability to leapfrog the United States in ways unimagined by the United States is severely restrained. On the other hand, if our general technological base is inferior to the Soviets, they have a much better chance of progressing in weaponry in ways we do not fully understand and consequently cannot prepare for. Thus, superiority of the general national technological base is critical to providing assurance against technological s prise and the greater our superiority over the USSR, the greater will be our assurance.

It is of significance to observe that defense expenditures probably have little to do with determining the strength of our national technology base. Most likely, it is the strength of our economy and our general

Table 2

REQUIREMENTS FOR PREVENTING TECHNOLOGICAL SURPRISE

1. Adequate Scientific and Technological Base
2. Understanding of Scientific and Technological Potential
   - New developments
   - Military potential
3. Understanding of Technology Needs
   - Crucial technology areas
   - Soviet technology potential
   - Soviet technology needs to provide crucial technological surprise
   - Technology requirements to prevent surprise
4. Development of Required Technologies
   - Understanding feasibility
   - Preventing surprise

orientation towards progress compared with that of the Soviet Union which governs the superiority of our national technological base. The defense program can momentarily stimulate the technological base in specific areas, but with regard to the long-term sum total of technological resources, the amount or orientation of the defense spending is likely to have little effect. This is not to say defense spending is not needed to prevent technological surprise; rather, it is to say that defense spending is not needed to maintain the overall long-term national technological base superiority required to prevent technological surprise. It is the defense spending which directs the general scientific and technology resources into needed defense areas. However, if defense spending is drastically reduced and the money is diverted to other sections of the economy, say ecology or energy fields, the net effect on the long-term technology base will probably not be great. Over the long haul it is not defense expenditures which determine the number of scientists and engineers graduated, the amount of laboratories developed, and the general progress made in science and technology.

Hence, as long as we maintain a healthier and stronger economy than the Soviet Union and continue to maintain a strong motivation towards technological progress we will maintain the necessary national technological base superiority. If at any time our economy becomes much weaker than the Soviet Union's, then our capability to prevent technological surprise will be seriously hampered due to the fact that we could not keep up with the general technological progress made by the Soviet Union.

The second requirement for preventing technological surprise is understanding the potential of science and technology. This includes understanding how far a given technology can be pushed, before a breakthrough is required. But more important, it consists of an awareness of new developments plus an understanding of the potential military significance of these developments. This requires: (1) a continual dialogue between the weapons analyst and the scientist or technologist, to make the weapons analyst aware of new scientific or technological discoveries, and (2) creative conceptual analysis to identify and evaluate possible high-impact applications of the

new discoveries. The critical aspects of this activity are timing and coverage of all technological areas and all types of weapon systems to ensure that a potential high-payoff capability for a particular mission area is not overlooked for an extended period of time. This activity is essentially that of conceptually identifying "technological opportunities." However, the principal purpose here is not to identify potential opportunities for our own weapons, but to provide a warning of what might be developed by the Soviets.

The third requirement consists of understanding technology needs to prevent technological surprise (see Table 2). This activity consists of: (1) identifying the means by which technology innovations can upset the balance of power (i.e., identifying crucial technology areas), (2) assessing Soviet technological capability in the crucial areas, (3) estimating Soviet technological needs to create a damaging technological surprise and (4) determining U.S. technological needs to prevent technological surprise. The identification of crucial technologies is an introspective analysis of the vulnerabilities, weaknesses and sensitivities of our weapon systems to establish how they might be neutralized by means of technological innovations. Assessment of Soviet technology potential is basically a Net Technical Assessment and projection confined to the crucial technology areas, to provide a base for understanding the technology needs of the Soviets to create a technological surprise. The Soviet technological needs are estimated by analyzing what technological capability is required to neutralize our critical weapon systems and comparing required capability with available capability. Finally, the means by which the United States can counter the potential threatening Soviet developments are identified and translated into specific U.S. technology development needs.

The above activities for understanding technology needs for preventing technological surprise are performed by weapons systems analysts and engineers using the technology base and technological potential described previously.

The fourth and final requirement for precluding technological surprise is the actual development of needed technologies and hedges. The technology development serves two purposes--to aid in understanding the feasibility of potential high-impact technology improvements and to provide the technology advances and hedges needed to counter possible technological surprises. As such it is commonly called defense technology base development and advanced weapon system development. The key point is that it is highly directed technology development. General technology development is provided by the national technology base. Attempting to improve the national technological base to help prevent technological surprises would not be effective as discussed previously. Thus the defense expenditures should be highly directed to those particular technological needs identified in previous activities.

Since technology development is a good deal more expensive than technology requirements analysis, it pays to take great pains in understanding the technology needs to prevent surprise. Thus, in the interest of providing the greatest assurance against technological surprise for the minimum cost, sufficient effort must go into understanding the technology needs and care must be taken to provide a proper balance between analytical and developmental activities.

It should be pointed out that one of the considerations in technology hedge development is the leadtime requirement as derived from the analysis of technology needs. The degree of feasibility or imminence of the threatening surprise will determine the extent to which any hedge must be developed. Again, considerable savings can be effected, through proper analysis, by preventing technologies being developed beyond the point necessary to provide sufficient lead or warning time. A further benefit of limited technology development is that it will retard the arms race.

2. R&D Planning Strategy for Preventing Technological Surprise

As we have seen, the key element for preventing technological surprise with a minimum of defense expenditures is careful planning to take advantage of our general superiority in technological base and to

establish precise technology development needs. In terms of specific requirements it is clear that there is little the Defense Establishment can do to improve the general technological base. We have a general technological base superiority and as long as we maintain a strong economy we should retain that superiority. Defense efforts to further the state-of-the-art in technology areas not identified as crucial to the technical surprise problem have little chance of increasing the assurance of technological surprise avoidance. Thus the most economic and satisfactory strategy is to take what the country provides in the way of a general scientific and technology base and add to it only in specific areas where technology development (1) has been identified as critical to our understanding of a threatening high-payoff technology area and (2) is needed to guard against identifiable and specific technological threats.

To preclude being surprised by scientific discovery and technological breakthroughs having high military payoff, effort should be made to improve the direct dialogue between the creative weapons systems analyst and the scientist or technologist. One method of accomplishing this is to encourage forums or societies which bring the weapons analysts and scientists together, perhaps by seeding highly qualified weapons analysts in all scientific and engineering societies. Another method is through special programs which force a broader scope of industry participation in the defense effort. Companies highly qualified in technology but unqualified in defense should be encouraged to participate. The government could supply the defense expertise directly or through project engineering contracts.

Another method of improving dialogue between the scientist and analyst is by means of improving and extending the IR&D program and university grant programs. The emphasis of these programs should not be on advancing the state-of-the-art but, rather, on identifying and examining the feasibility of high-payoff applications. This would bring weapons analysts into the scientific and technological environment of universities and industries.

The establishment of technology needs for the prevention of technology surprise is the single most important effort in avoiding the surprise threat. This is a complex and extensive weapon system analysis and planning effort. Consequently, a separate DOD office to be responsible for this effort is desirable and would likely result in much better utilization of defense resources. The function of the agency would be to coordinate and integrate all activities for determining technology needs for avoiding technological surprise, and it would be responsible for establishing technological development guidelines and priorities. Such an activity could be a logical extension of the Net Technical Assessment program and could be labeled Technology Surprise Assessment. A key function it would perform that is currently not being performed in any systematic manner is the analysis of the technology developments required to upset the balance of power. A yearly estimate of the technological surprise threat potential would be a natural result of this activity.

Specific technological needs for preventing technological surprise should be an input in the R&D planning process, along with other needs such as modernization requirements, bargaining chip requirements, etc. The R&D program would then be shaped to include specific technological advances necessary to avoid technology surprise. This in essence would eliminate the ill defined and impossible defense R&D goal of technological superiority. Rather, it would be a goal of selected technological superiority (where necessary to understand and prevent technological surprise). Selected technological superiority provides a clear and understandable rationale for defense technology base development, which is not the case with the rationale of technological superiority.

It should be noted that the current R&D planning process of bottom up requirements generation and the top down cutting to fit the budget brings the R&D planner and technologist together in an indirect manner, and is conducive to the development of high-payoff technologies. Such a process should be continued, but with the added guidelines and priorities as specified by the assessment of technological needs to prevent technological surprise.

F. Summary of Major Findings

This paper addressed two key questions: What is the nature and feasibility of the technological surprise threat today? How can it be prevented with a minimum of defense effort? The major findings are summarized below:

- The prevention of technological surprise is a long-term as well as a short-term requirement. We need an R&D planning methodology to ensure against technological surprise with a minimum of defense expenditures and without unnecessary enhancement of the arms race.

- To qualify as a damaging technological surprise, a technological development must satisfy two requirements: (1) it must have the potential for dramatic and intimidating improvements in military effectiveness such that its implementation will upset the balance of power and (2) it must contain the element of surprise, i.e., it must not be detected or recognized until it is too late for an effective response.

- Damaging technological surprises have occurred in the past, but by and large they have been rare. The reason for this is that weapon development is generally an evolutionary rather than revolutionary process, involving many incremental improvements rather than outstanding breakthroughs. The development of a true technological surprise requires unusual foresight and cooperation on the part of the scientist, engineer and defense planner.

- Today's U.S. forces are not immune to technological breakthroughs which could render them ineffective. Scientific or technological breakthroughs which could neutralize our strategic nuclear forces or our general purpose forces are in the realm of possibility.

- However, with our present technological superiority and technological development activity which is pushing out the frontiers of all weapons technologies, it is extremely unlikely if not impossible that the United States could be surprised or caught off guard by a damaging technological breakthrough. We would be susceptible to surprise only if we relaxed our guard through a combination of poor planning and a significantly reduced technological development effort.

- The minimum requirements for preventing technological surprise consist of: (1) general national technology base superiority, (2) prompt understanding of the military significance of scientific and technological innovations, (3) careful and continuing planning of technological development needs for preventing technological surprise, and (4) development of required defense technologies and hedges.

- The adequacy of the general national technological base depends primarily on the strength of the economy, not on defense expenditures. The function of the defense effort is to focus and augment the general technology base in crucial areas, not to provide general technological superiority.

- The prompt recognition of the military potential of scientific and technological innovations is critical to preventing technological surprise. This requires a dialogue between the scientist and the weapon systems analyst which must be encouraged by scientific and engineering forums and societies, broad contract participation in the defense R&D effort, and strong, well integrated university grant and IR&D programs.

- The key to the avoidance of technological surprise as efficiently as possible is careful planning to establish crucial technology development needs. This should be the responsibility of a special office which would identify the potential technology developments that could upset the balance of power and convert these into specific technology development needs through integration of net technical assessments, technological opportunities and countermeasure requirements.

- The basic R&D planning strategy governing technology development for avoidance of technological surprise can be termed "selective technological superiority." This consists of specific technological developments and hedges for the purpose of understanding and preventing damaging technological surprise. The essence of the strategy is a generally superior national technology base, prompt awareness of the significance of technological opportunities through a continuing dialogue between scientist and defense planner, careful planning to determine precise and crucial technology needs for preventing technological surprise and, finally, the fulfillment of the technology needs through advancement of the defense technology base in the areas selected as crucial to the understanding of the military potential of science and technology and to the development of a satisfactory hedge posture.

OFFENSIVE VERSUS DEFENSIVE TECHNOLOGY

by

Gen. Richardson

OFFENSIVE VERSUS DEFENSIVE TECHNOLOGY

SUMMARY

This study addresses the question of the relative emphasis given in R&D to offensive versus defensive weapons systems in the general purpose forces. Most U.S. R&D efforts cannot be identified with advancing either offensive or defensive capabilities--particularly in the general forces area--primarily because most R&D programs serve to advance both capabilities. Furthermore, the long leadtime in R&D programs and the procedures and policies in vogue today tend to dissociate ("decouple") the technology base R&D programs from specific weapon system developments. A review of the R&D programs outlined in the DOD RDT&E presentation to the 93rd Congress for the FY1975 budget indicates no identifiable bias in favor of offensive or defensive force capabilities, nor did the review suggest any way to accurately measure such bias if, in fact, it did exist.

A balanced U.S. RDT&E effort--assuming it is the optimum balance for U.S. security purposes--should not logically favor the offense and defense equally. The geographical situation of the United States relative to potential threats and current U.S. national security concepts and policies inherently establish a requirement for predominantly offensive force capabilities. The United States, for example, has no common frontiers with major enemies and hence has a minimum requirement for D-Day defensive capabilities, and its general purpose forces have primarily an expeditionary role which is essentially offensive. Furthermore, peacetime U.S. forces deployed to overseas defensive tasks, as in NATO, cannot be considered permanent and must be prepared for deployment at any time; hence, in light of R&D leadtimes, such essentially temporary defensive commitments should not be permitted to unduly influence overall RDT&E orientation.

The favoring of offensive or defensive force capabilities on the basis of "lessons learned" or of "changing operational requirements" can only be done in timely fashion by making selections from new technologies and new weapons ready to go into production and deployment. At this point in the RDT&E cycle, much of the R&D work has been completed and is already in hand. This suggests that the problem of emphasis on offensive versus defensive capabilities in the area of R&D is one of system selection for deployment rather than one of RDT orientation.

Technological base programs of the United States should not be influenced or limited by treaty, moral, arms control, or other similar and possibly nonpermanent manmade constraints. Due to the long leadtimes involved in developing new capabilities in the present era of technology and due to the uncertainty of perpetual adherence to such manmade--essentially political--constraints, these should only be applied to the RDT&E cycle at the point of decision to produce and deploy affected capabilities. They should never be permitted to prevent the pursuit of basic and exploratory research in the areas concerned.

No nation can pursue "responsive" RDT&E policies and hope to maintain an adequate level of national security. Since "responsive R&D" means that the United States will not initiate new weapon development programs, or pursue new defense technologies, except in response to identified efforts in these areas by others, such a policy can only lead to technological inferiority in all areas due to a combination of leadtime and difficulty in obtaining intelligence in this area. The argument, therefore, that aggressive R&D undertaken independently of identified new threats is provocative of arms races--while possibly true--must be rejected on the grounds that the alternative is technological and eventual military inferiority. This is an important message that must be clearly conveyed at all times.

OFFENSIVE VERSUS DEFENSIVE TECHNOLOGY

A. Purpose

The question of the relative emphasis given in R&D to offensive versus defensive weapon systems may come up during the Defense Departments annual budget presentation to the Congress. Most likely questions would be with respect to the balance within RDT&E programs in support of General Purpose Forces.

While this may be deemed a logical concern, there are no simple answers. Any evaluation of relative emphasis must first depend on how the various elements of the weapon systems that benefit from technology efforts are categorized as between offensive and defensive. Once this is done there would remain the problem of base line determination. An optimum U.S. force posture, in light of such basic considerations as geography, national policy, and known force commitments, is certainly not one that would equally emphasize the offense and the defense. Past experience, confirmed in this study, suggests that such a posture would tend to favor offensive capabilities, all other considerations being equal. Should this be the case our R&D emphasis should reflect it.

Should an imbalance in U.S. RDT&E programs exist, the question will arise as to whether it can be corrected and how. The long leadtime in most R&D programs, taken together with the probability that any imbalances as between offensive versus defensive contributions will only become apparent in their final phase--or when the end product is in the hands of the troops--raises questions as to how and where useful adjustments can be made, or whether they are in fact needed. For instance, imbalances in today's capabilities could well have their origin in technology base programs initiated during and shortly after the Vietnam experience--an influence no longer pertinent to today's technology base starts, hence unlikely to father future imbalances in the 1970s.

In technology policies, as in strategic concepts, more variants are envisioned and discussed than can be implemented in practice. R&D orientation, in the real world, may well depend more on such basic influences as budget decisions, technological possibilities, and the technical threat than on any specific desires to emphasize a given role, or favor some segment of the forces. Add to this the unpredictability of the fallout from technological base programs, and the selectivity they frequently provide for operational applications, and one can argue that the problem of offensive versus defensive balance is not one of relative emphasis of R&D but rather one of the choice of the end products of R&D programs for weaponization and production.

Nevertheless, if the question of relative offensive versus defensive force capabilities is attributed by some to R&D emphasis, and may be raised as such in congressional or other presentations, an analysis of all the above considerations is pertinent to providing proper answers. THIS IS THE PURPOSE OF THIS PAPER.

B. Background

Any scrutiny of any aspect of the U.S. RDT&E programs must be made within the context of past and current trends and policies in research and development. Only within the framework of the role allocated to U.S. R&D during the past decade can we make a fair evaluation of its contribution to today's force capabilities. If there are shortcomings, or imbalances, in the latter, these must generally be attributed to decisions made some years back. Likewise shortcomings in the late 1970s and early 1980s can be attributed to what we do today. If there is one area of national security in which the old saying is valid that "to understand the future one must first understand the past," it is in the field of research and development.

World War II initiated the technological revolution in armaments. The massive financial and manpower investments in research prompted by the war were on the whole not reflected in dramatic changes until the early 1950s, when our operational capabilities, and strategic and tactical thinking, were

obliged to adjust to the advent of jet aircraft, atomic weapons, and greatly advanced communications, electronic, and reconnaissance systems. The sustained, high-risk, and well-funded U.S. R&D programs of the 1950s gave us missiles, submarine-launched systems, and space capabilities. A major spinoff from the development programs for these were the integrated circuits and solid state electronics that subsequently contributed to a wide array of general force weapons and systems improvements and innovations. The 1940s and 1950s were clearly a period of technological growth and innovations for the military. Throughout this period there was no question about the United States having both technological and military superiority.

In the early 1960s, U.S. policy towards the pursuit of military research and development changed. Starting in 1961, R&D funding began to decline as did the number of active innovation programs being pursued by the services. Many new development programs and proposals, endorsed by leading U.S. scientists and military authorities, were consistently denied or underfunded by the then administration. Investments in basic research, such as the program to produce boron and carbon fiber materials, were terminated or underfunded. Advanced capabilities, such as MRBMs for NATO, the boost glide system--DYNASOAR, and the airborne missile SKYBOLT, were canceled. Concurrently, DOD adopted a low-risk approach to new weapon procurement. This required that all pertinent science and technology be in hand before proceeding to systems development. There were many reasons advanced for this low-risk approach: arms control aspirations; antinuclear--return to conventional--policies; economics, the demands of the Vietnam war; and antitechnology attitudes typified by the so-called technological plateau theory, but the result was to slow down military innovation.

Our concern in this study is not with the reasons for the U.S. change in technology policy, but with its impact on today's programs.

The United States lost, or gave up, its momentum in R&D in the 1960s partly due to decisions of our own making and partly due to the impact of the technological revolution of the 1940s and 1950s.

The principal elements of our own making, some of which are still in effect today, are: first, the adoption of the low-risk procurement policies typified by DOD Directive 3200.9; and second, the increasing resistance to funding innovation programs except in response to clearly identifiable innovations by the USSR. Instead of innovating wherever it would give the United States a clear military advantage, we began to innovate only where necessary to deal with the innovations of others. Defensive, or responsive, innovation can only lead to eventual technological inferiority.

The principal elements attributable to the technological revolution of the 1950s are: first, the increased leadtime required for the development of new and advanced systems which greatly reduced our ability to justify starting new programs on the classic grounds of either the threat or a defensible military requirement; and second, the enhanced importance of breakthroughs to our national security. These, in some minds at least, portrayed military R&D, and particularly innovation, as a destabilizing, provocative, antiarms control, and hence undesirable, activity.

The war in Vietnam led to a major diversion of funds to rebuild our conventional capabilities. Conventional weapon systems, such as machinegun development, had been neglected in favor of high-performance missiles, aircraft, and space systems, most of which could only be justified in conjunction with the use of atomic firepower--at least cost effectiveness wise. Since an offensive against North Vietnam was a No No, emphasis was given to barrier, warning, close support and similar defensive systems. Rightly or wrongly, this reorientation of defense R&D arrested the momentum in the U.S. effort to advance the frontiers of technology while producing a major contribution to the capabilities of the general purpose forces. Out of the Vietnam R&D orientation came precision guided missiles, major advances in penetration aids, combat helicopters, improved antitank and antiaircraft systems, and whole new generations of small and medium caliber conventional arms.

Since 1970 the emphasis on high-risk versus low-risk R&D appears to have returned to what might be described as a middle position. Funding remains inadequate to pursue all the technological possibilities that offer promise of giving U.S. forces a decisive advantage, and the high-risk approach to procurement remains unacceptable. On the other hand, the stifling effect of DOD 3200.9, and its related low-risk procurement policies such as the Total Procurement Package Concept (TPPC), has been recognized, and these have been abandoned. Although procurement remains decoupled from the technological base effort, the acceptance of prototype developments, and "fly-and-buy" competitions, allows some reduction in leadtime and more latitude in introducing technologies not all of which were in hand prior to systems consideration. The "technology is provocative" and "responsive R&D only" schools are still active but less vocal than in the 1960s.

Whether today's policies and procedures are optimum, or not, is doubtful. Much depends on what the USSR does. The arresting of U.S. R&D momentum in the 1960s, along with the cancellation of some of the advanced products of the momentum of the 1950s, cost us our strategic superiority. Whether this will now take America from a position of strategic parity to strategic inferiority remains to be seen. Hopefully, SALT agreements will prevent this if our technological initiatives can't.

Any efforts to orient today's R&D programs must be painted against the above background. These historical considerations, amplified in the following discussion, have a major impact on the balance of current programs. They also suggest some of the limitations to influencing R&D as well as the problems associated with any efforts to do this. It is therefore in the context of the above situation, that we must consider if our present General Purpose Force posture suffers from the over emphasis of defensive versus offensive innovations, or if the allocation of R&D programs as between those that support our strategic versus general purpose forces needs to be reviewed and/or adjusted.

C. Statement of the Problem

In the present era of ever more sophisticated weaponry, technological superiority can compensate for numerical inferiority on the battlefield. In view of this a properly balanced and well oriented U.S. R&D program in support of our general purpose forces is not only desirable but essential. The balance, and orientation, of such a program will be governed primarily by U.S. national security requirements; current and prospective overseas commitments; and technological possibilities. Budget and arms control considerations, and cost effectiveness, will also impinge upon this balance and orientation along with current strategic and tactical concepts.

U.S. R&D programs must be pursued for the benefit of both offensive and defensive force capabilities. They also have to contribute equally to the improvement of both strategic and general purpose forces. The extent to which this is being accomplished requires periodic scrutiny. Unless this is done, from time to time imbalances may come about inadvertently and as a result of vested interests; overreacting to lessons learned from the most recent military experience; undue emphasis on an element of the forces, or a segment of technology, that is attracting attention at the moment; or budget cutting actions.

The threat to the maintenance of balanced contributions from our Research and Development Programs to all segments of the forces stems, to a large extent, from the long leadtimes in modern R&D programs. An imbalance or wrong orientation in the U.S. Basic, or Exploratory, research efforts today could go unnoticed until it was reflected in technological hence operational inferiority in some segment of the forces several years hence. Leadtime has in recent years tended to decouple the R&D community's ability to respond to short-term operational requirements. As this occurs, more and more R&D programs are initiated and pursued on the basis of technological possibility rather than in furtherance of military requirements.

Concern has recently been expressed in some quarters to the effect that U.S. R&D efforts may be unduly weighted in favor of technologies serving defensive force capabilities. Whether this is so, and if so by design or as a result of the various trends, policies, and conditions that continually influence the orientation of R&D, is by no means clear. In view of the leadtime problem, and of the difficulty--if not impossibility--of identifying technology base research efforts with either offensive or defensive force improvements, any operational imbalance today may well be the result of R&D emphasis undertaken during, or as a result of, the Vietnam experience. "As the twig is bent so the tree shall grow."

As a first step in scrutinizing R&D emphasis we need to identify the principal forces and considerations that normally influence the direction of U.S. R&D programs. We also need to know at what point in the average R&D program life cycle orientation is practical, as between offensive and defensive, or strategic and general purpose forces. With these factors as essential background information, the responsible planners can then determine if any adjustments are needed, and if so, where they can most usefully be made.

> The problem addressed in this paper is to determine the principal factors that most influence the orientation and balance of the U.S. R&D effort, with emphasis on their impact on offensive versus defensive program priorities.

Given an understanding of these factors, and of the trends they portend for the future--and of how and where influence can best be brought to bear in light of these--it should be possible to determine the extent to which imbalances as between offensive and defensive efforts exist, or not, and if so what should, or can, be done to correct these.

This study does not attempt to determine if in fact imbalances do exist at this time. Our preliminary examination of the possibility of doing this suggests that it would be beyond the scope of this effort; would be of doubtful value if attempted by virtue of the near impossibility

of getting agreement on what is defensive versus offensive in many new weapon systems and components; and could only be usefully undertaken in light of the findings of the problem addressed herein.

D. Discussion

The objective of the U.S. technological base effort should be to insure, to the extent possible, that the United States maintains technological superiority, or at minimum parity, with all potential enemies in order to insure that we will have the capability to provide our forces with the latest and best weapon systems, and have the best prospects of realizing breakthroughs of concern to our security, or alternately, of responding in timely fashion to breakthroughs realized by others.[1] The purpose of the advanced development, engineering, and production phases of R&D is to translate the products of the ongoing technological base effort into new weapon and support systems that will enhance the combat capabilities of the forces. Any "orientation" of the R&D effort to favor any type or category of force would normally occur at the onset of this latter effort.

If U.S. forces are to enjoy the most advanced weapon systems possible, in the timeframe, the R&D effort overall must be so organized and managed as to cover the entire spectrum of potentially useful technology and push the state-of-the-art in all key areas. A good technology base program, backed up by adequate funding and production capabilities, is important but not the only factor in insuring advanced weapons. A separate and equally important requirement, all too often overlooked in evaluating R&D, is the ability to translate the findings of the technological base programs into hardware innovations. This is sometimes referred to as the "R&D coupling problem." Its solution requires adequate, and continuing, means of communication between our scientists and engineers. It also requires participation of imaginative commanders, operators, and planners in the R&D process at some

---

[1] DOD FY75, RDT&E Budget Presentation, p. 1-4, para. 1.2.1.

point in the cycle between the technology base and advanced development, or engineering, steps. History is replete with examples of new inventions and scientific advances that were not translated into practical uses for months, or even years, after their initial discovery. Only if the United States can research, innovate, engineer, and produce as well, or better, than its enemies will our forces be provided better weapon systems than those provided to our enemies.

An important adjunct to our capabilities is the effective use of allied R&D capabilities and activities to supplement those of the United States. This aspect of R&D should be kept under constant review, for there is evidence that a combination of economy and security has reduced the U.S. capabil ty to draw upon allied scientific talent particularly in the technological base area. This is discussed in another section of this study.

Since World War II, technology has become increasingly important to the capabilities of the forces it serves. As weapons become more sophisticated and accurate, quality tends to overtake quantity as the dominant consideration in combat operations. Increased sophistication has also brought with it increased leadtimes in the overall development process. Both these considerations have greatly increased the cost of the R&D effort and of its end products. Long leadtimes increase the threat posed by decisive breakthroughs since earlier identification in order to respond is required. This has placed a high premium on technological intelligence.

Long leadtimes have also resulted in some decoupling of operational requirements and of "lessons learned" reactions from R&D program planning. The classic requirements cycle, while still retained in theory, has all but disappeared in practice. Field Commanders and operators still establish their hardware requirements in light of their missions and of the threat at the time. Today, these must be met largely from available systems, modifications of these, or at best technology already in hand. With the advent of leadtimes in years, no one can foresee the threat, specific operational needs, or even who the enemy may be, with any certitude at the

time new programs in technology are initiated. The result of this is that most new programs are initiated on the basis of what the technological possibilities are rather than on the basis of clear military needs. It also makes it much more difficult for DOD to defend new programs since they generally cannot answer the classic congressional questions of: "How and where will it be used?" and "Is the enemy building one?" particularly when arguing for funds for a program whose end product will not be available to the forces for 7 to 10 years at best. The only and proper answer to these questions is: "If we don't pay for the necessary research now the United States will not have the option of building it 5 years from now, should we discover our enemies have been working on it and will build and field it!!" Unfortunately, this seldom sells high-cost programs particularly when they are opposed by "responsive R&D" arms control advocates who consider any progress not necessitated by a prior threat as provocative, A classic victim of this problem was the Air Force SCRAMJET programs.

All the above considerations influence our ability to orient R&D towards specific goals.

It should be apparent by now that there is some question as to whether R&D can in fact be oriented in any timely fashion to specific ends, or whether it is a self-adjusting, somewhat random activity that if pursued across the board will produce end products from which a choice can be made and orientation obtained in this way.

In practice we can and do fund programs to support improvements in specific weapons and support areas. This can be deemed a form of orientation since we can concentrate our funding and efforts on systems clearly categorized as being defensive, offensive, strategic, general purpose, or support. Even in this regard selectivity is constrained by certain fundamental considerations that include elements of inevitability, geography, and scientific progress made in areas wholly unrelated to military requirements.

One of the findings of this study is that these fundamental guiding considerations dominate the selection, and direction, of most R&D programs of consequence, and this to such an extent that the question of orientation is somewhat academic except as it may apply to the "selection for production" process rather than to the "initiation of research process." Four of the basic factors that seem to be dominant in the R&D influence process are discussed in some detail below. These are: the shift from mass to technology; the impact of geography on U.S. R&D; leadtime and its effect on the decision process; and the impact of procurement policies on new weapon prospects. Each of these, and their impact on Offensive versus Defensive RDT&E orientation, is examined in the following paragraphs.

1. Leadtime Considerations

The time required to develop, test, procure, and field new sophisticated weapon systems has steadily increased since World War II. This has had three important, though not too well understood as yet, consequences:

- A tendency to decouple the early phases of R&D from both military requirements and enemy weapon programs.
- Increased difficulty in justifying sizable sums for early phases of R&D programs.
- Decreased prospects of timely reaction to new, and unanticipated, enemy innovations and breakthroughs in new weaponry.

The classic requirements cycle for new military hardware started with a "need" established by operational commanders in light of their missions and of the enemy capabilities facing them. In theory, the responsible military commander stated what he needed to do his job, and technical and logistics commands indicated the extent to which they could meet these needs and the cost, and the high command decided--in light of policy and budget considerations--whether or not to direct the technical/logistics side of the house to meet the new operational requirements. Unfortunately, this simple, ideal sequence of events can seldom be followed in the real world of today even though the "image" of this procedure persists.

When it takes several years to go through a normal RDT&E cycle and, in addition, if: prototype tests and competitive efforts are required; preproduction actions are deferred until all technology can be shown to be in hand; and procurement is further delayed by debate, controversy, or merely processing through the budget and approval process; the leadtime from the establishment of a new requirement--or birth of a new weapon concept--to its operational availability can be, and has been, in excess of five to seven years.

No operational commander can be sure what he will need five to seven years hence. Both the threat and his mission will probably change in that time. He himself may no longer be in command. Under these circumstances neither the threat nor the mission can be forecast with confidence. This means that as leadtime increased, along with the sophistication of weapons and of the procedures for their acquisition, operational commanders had to shop more and more among systems already in production, or at minimum in preproduction, to meet their needs. This, in turn, allowed others to determine the new innovations that will be pursued, in the initial phases of most R&D programs, based more on what the state-of-the-art is at any time than on definable threats or defensible operational requirements.

If in practice our new initiatives stem more from recognition of a technological possibility rather than from any clear-cut military requirement, there is no reason to assume that such possibilities will occur predominantly in areas of interest to any one mission area or segment of the forces, such as for defensive versus offensive activities. If there is an imbalance in the numbers, and types, of innovations as between the offense and defense, it would then stem from the selection made by commanders out of available systems for production rather than from any imbalance or bias in R&D programs.

- Whether desirable or not, technological possibilities, not operational requirements, primarily influence the selection of new R&D programs due to leadtimes. This also reduces the prospects of "lessons learned" being translated into timely changes.

Lengthening leadtimes have made it very much harder to justify R&D spending. When costly programs are proposed, both responsible authorities and critics invariably ask two key questions: (1) How will the weapon be used when and if successful? and (2) Must we develop it because our enemies are doing so? On long-leadtime systems neither question can be effectively answered. How something new and untested will be used five to ten years hence can only be conjecture--we aren't even sure who the enemy will then be. It is hard enough for the intelligence community to give certain answers on equipment in test and production--witness the ABM and MIRV controversies. Intelligence on technological research still in laboratories is next to impossible to obtain.

- The best argument for incremental funding of long-leadtime research is to show that if we don't get the S&T in hand now the United States will not have the option to build the system (item) if and when we discover the enemy has it, or we see a requirement.
- Technological base programs that cannot as yet be related to either operational uses, or similar enemy developments, can hardly be identified as serving solely or even primarily defensive or offensive purposes.
- The decoupling of ongoing operational needs from the prospects of satisfying these with new systems in a reasonable timeframe argues for getting all potentially important new technologies in hand before allowing policy, arms control, treaty, or other changeable constraints from stopping further spending. These should impact systems financing not technology base programs.

As relative technology becomes a more important consideration to the outcome of battles or wars, technological breakthroughs pose even more serious threats. Were the Soviets to suddenly deploy a means of tracking all U.S. submarines, the impact of this on the balance of power needs no elaboration. A laser ABM, or close support antiaircraft systems unmatched by equivalent capabilities on the other side, could prove decisive long before countermeasures could be devised and fielded. Such development could be perfected and to some extent tested in secrecy considering the limited capabilities of technological intelligence.

The only effective guard against breakthroughs is to maintain a high level of basic and exploratory research in all areas of technology--regardless of identifiable requirements, threats, or political and arms control factors. Not only is this essential to give the nation at least a chance to devise countermeasures in time, but it also is essential to our ability for earliest detection of breakthroughs.

Technical intelligence is at best hard to get. We can be sure that prospective breakthroughs of importance will be kept secure and secret for as long as possible. The first indications will likely be fragmentary and inconclusive. Only if these are brought to the attention of U.S. scientists working in parallel fields are they likely to be recognized. This argues not only for broad U.S. programs but also for close coordination between intelligence-gathering groups and U.S. researchers in potential breakthrough areas.

Finally, consideration must be given to the fact that warning time of technological innovations is relative not only to the level of effort underway on equivalent systems, or countermeasures, when the warning is received, but also the leadtime required to respond effectively. In the case of high-cost, high-technology systems a lag in relative research and development efforts of several years might not be made up even given as much as a year's warning. If we knew today that the USSR would field an effective anti-submarine satellite in one year's time, it is doubtful if maximum funding and effort on our part could field an effective counter in a year from a standing start. The same can apply to less large but equally vital general purpose defensive or offensive weapons.

- Good technical intelligence is more and more important since time in which to respond to breakthroughs can be critical. The time required to respond is also a function of the level of ongoing R&D in the area concerned when the new threat is detected, as are the prospects of early detection from fragmentary intelligence.

2. Geography and R&D Emphasis

There is a relationship between a nation's location on the globe and the technologies that can best serve its security goals. While seldom discussed by planners "blinded by the obvious," the geographical factor is a priority consideration in the design of many major weapon systems and items of equipment.

A country having a common frontier with a possible enemy and little depth to its vital cities and military installations requires quick reaction, primarily defensive, capabilities. Its fighters must have a high rate of climb, if necessary at the expense of range. It can exploit nonmobile mine, missile, radar, and other antitank, personnel, or aircraft systems optimized for operational use from their peacetime locations. Inexpensive antitank weapons, like LAW, can be developed profitably for distribution to the militia, police, or stay-behind groups, and the national communications and air traffic control nets can substitute to some extent for costly mobile systems such as AWACS. Germany and Israel are current examples.

The United States has no common frontier with a likely aggressor except in remote arctic areas. Since first priority is the defense of the country, the only first priority technologies for this purpose are those that can cope with incoming missiles, aircraft, or space-based systems. Our general purpose forces are primarily needed for expeditionary missions. Either they are deployed in overseas areas, as in NATO and Korea, or they must be ready to move to threatened allied areas when emergencies occur. In the former case their presence cannot be considered permanent, nor are they usually deployed forward on the sites to be defended.

U.S. general purpose forces must envision moving before fighting. They must be prepared to fight in remote locations with little or no infrastructure useful to them. They may have to deploy to the combat areas in the face of active opposition. And, since in most cases they will be going in to support indigenous allied forces, they have to consider the command, communications, supply, and other interface problems this can pose. These considerations have a major impact on U.S. R&D trends and priorities.

If mobility is a prerequisite to combat operations, and our forces have to be prepared to deploy against opposition, those technologies that contribute to the ability to deploy and support effective forces overseas must have high priority. Offensive capabilities cannot be neglected in favor of emphasizing tactical defensive systems if offensive operations may be required in order to reach the areas to be defended! In principle, expeditionary forces emphasize offensive weapons, even though they may be deployed in early phases to assist an ally's defensive efforts.

Other geographical considerations include the importance of naval forces to the general purpose package. Technology that permits carriers to support expeditionary efforts by U.S. Army and tactical air units is clearly high priority. Except for ship defense these would emphasize aircraft strike and penetration capabilities--all essentially offensive missions. The same applies to marine assault operations.

- U.S. general purpose forces have primarily an expeditionary role by virtue of geography. Thus offensive capabilities and strategic mobility are a vital requirement and should logically be emphasized in U.S. R&D programs in support of these forces.

3. Mass Versus Technology

Before World War II relative mass, in the military sense, generally referred to relative numbers of combatants. As the role and importance of firepower increased references to relative mass included the number of firepower delivery systems, and the vehicles associated with these. The capability of general purpose force thus came to be measured in terms of the numbers of men and delivery systems--guns, tanks, ships, planes, etc.--rather than in terms of the amount of effective destructive power that they could deliver. Parenthetically, this is a current problem in assessing SALT Agreements since the tendency is to focus on the number of missiles, bombers, and MIRVs allowed each side rather than on the relative ability of these systems to destroy desired targets, which ability is determined as much by their

accuracy, reliability, ability to penetrate, and weapon yields and configurations as it is by numbers of vehicles or warheads.

The tendency to measure relative military capabilities in terms of relative mass, and to equate mass with numbers of men and weapon systems, clouds the increasing role that technology is playing in determining the outcome of battles. The relative ability to destroy a given target is less and less dependent on the numbers of delivery systems available, and more and more dependent on their technological sophistication. Yet, so long as mass remains a dominant consideration to both sides, technology merely raises the effectiveness of both sides without being allowed to materially reduce force levels. The increased effectiveness is utilized up to a point in shortening the duration of the battle or buying "insurance" by taking on more targets. Beyond that it becomes overkill, pursued only because the other side, if equally wasteful, must be matched quantitatively under our "relative mass" philosophy. The first deviation from the classic insistence on seeking superior "mass" came with studies of the impact of tactical nuclear weapons in NATO in the early 1950s. Given the tremendous destructive power of an atomic weapon, and the ability to offset inaccuracy with its area effects, it became apparent to students of this type of warfare that mass would henceforth have to be thought of in terms of targets destroyed, or kilotons delivered on target, rather than in terms of the numbers of guns, aircraft or ships available to make the deliveries. It now appears that the same reasoning may soon be extended to conventional weapons by virtue of technological progress, particularly in the area of accuracy.

The ability to destroy an opposing threat, while avoiding one's own destruction, remains the key consideration. But, the numbers of men and machines required to do this, even in conventional war, should logically decrease as the effectiveness of the weapons increases. The military should, in effect, benefit from greater productivity and automation. Unfortunately, in the defense sector this trade-off has, until recently, been traditionally resisted. All concerned preferred to improve "quality," with the latest products of technology, while at the same time retaining quantity. This has proved costly, but has succeeded so far except in cases where either cost or physical circumstances have forced a choice.

The inevitability of increasing reliance on technology at the expense of reduced numbers is quite clear. Where this can now be safely done, and to what extent, is less clear. Nuclear technology obviously decoupled firepower possibilities from mass as traditionally defined. The consequences of this were first felt in the strategic force arena. The thousands of bombers required to have a useful impact in World War II, with the associated industrial mobilization and long build up phase, are not even contemplated today. No one seriously argues that the outcome of a strategic exchange, should one occur, will be decided by the forces and weapons in being at the onset. Thus, in the Strategic Force area quantity of vehicles, while still a consideration, is no longer "open ended." It has increasingly been limited by cost or subordinated to accuracy, survivability, warhead yields, and payloads, that have become equally important considerations. What does this trend portend for future general purpose forces?

There is good reason to believe that the tactical arena is following in the footsteps of the strategic arena and beginning to substitute technology for mass. This is taking place without resort to atomic firepower. It is a tremendously important trend from the point of view of developing, and maintaining, cost effective defense forces. By virtue of atomic technology the relatively small British and French nuclear forces constitute both a threat and a major deterrent to war. These countries could never have afforded to raise an equivalent conventional strategic capability. If highly accurate battlefield conventional weapon systems could also act to equalize countries with large differences in their ability to field forces in quantity (mass), the prospects for self-sufficiency in defense in many areas would be greatly increased.

If the United States can improve the accuracy and lethality of its conventional weapon systems to the extent that smaller general purpose forces can accomplish most of our national security objectives, we may be able to maintain a cost effective mobile force structure notwithstanding current pressures for reduced defense spending and the loss of allies and overseas bases. This may also offer the only hope for smaller nations like Israel to defend themselves effectively against larger neighbors.

NATO moved towards the full exploitation of technology in the early 1950s when it became clear to the then thirteen nations at the Lisbon Conference that they could not afford to raise the forces needed to match the Soviet mass facing Europe at that time. The new NATO strategy was based on anticipated reliance on tactical nuclear technology, an approach that was later rejected under the pressures of political and moral forces. The fact that it was rejected in the late 1950s for essentially political reasons did not lessen its military validity. The NATO program was then solved by adopting a so-called flexible, dual force posture which left relative conventional force capabilities (mass) as the dominant consideration, along with their high cost.

Since Vietnam, developments in precision guided missiles (PGMs), antitank weapons, antiaircraft systems, advanced fighters, and soon, possibly, lasers seem to offer prospects of approaching a "one shot one kill" capability that could only be had until now by exploiting the area effects of atomic firepower. If this is the case and the new conventional weapons can do the same job, cost-quantity wise, as small atomic weapons, but with less incidental damage and political concern, we can hope to realize the benefits of atomic battles without the liabilities of having to use atomic weapons. We are still a long way from this goal, but our new conventional weapons are approaching it, as evidenced in the 1973 Israeli-Arab war. The number of shots that now have to be fired at any one target--tank, aircraft, bridge, etc.--to get a kill has been greatly reduced. This, in turn, reduces not only the number of delivery systems required to do a given job but also the transportation requirements to move and support them.

Conventional weapons technology that increases the ability to destroy targets with less expenditure of munitions also promises to change the nature of conventional conflicts in a significant way. As reliance for target destruction is placed increasingly on expensive and sophisticated weapon systems, the decisive phase of conflicts will tend to move closer to their onset. The strategic experience will be repeated in the tactical arena. More importance will have to be given to the forces in

being, or to those immediately mobilizable, and the relative importance of the industrial and mobilization base cannot but decrease. The classic conventional war-of-attrition phasing of fallback, holding, buildup, and counterattack periods each lasting months, or even years, will become a thing of the past as advanced technology permits small ready forces to do the job, largely with weapons in hand on D-day. The long leadtime in the development of these modern sophisticated weapon systems, and the small quantities we can afford to buy that preclude mass production preparations, suggest that "holding" and "buildup" phases for wars of attrition with this type of equipment would be far too long and costly for any country to attempt.

- Relative capabilities will become more and more dependent on relative technology than on relative mass. This has advantages, but also places increasing importance on a continuing and highly effective U.S. R&D effort in both defensive and offensive systems and their support.

- Some implications of increasing reliance on more sophisticated weapons include (but are not limited to):

  - Enhanced importance of ready forces
  - Greater technical training demands
  - Increased decisiveness of the initial phase of operations
  - Reduced overall logistic requirements
  - Sophisticated, responsive, command and control needs
  - Decreased reliance on the mobilization base in wars
  - Enhanced importance of technological intelligence.

The above implications point up the importance of balanced, peacetime, offensive and defensive force R&D programs. Wars can't be won by defensive operations alone. If the decisive phase occurs near the onset, and there are little or no prospects of a buildup before counterattacking, there can be no case made for emphasizing defensive systems as one might have in anticipation of past long "holding" phases in historical wars of attrition. If anything, the changing emphasis from mass to technology will call for priority being given to R&D programs that will most help offensive force capabilities.

4. <u>High-Risk Versus Low-Risk Procurement Considerations</u>

The ability to field the most advanced, highest performance weapon systems before any other nation can field these against us is somewhat dependent upon the procedures for weapons development and procurement in vogue at the time. High-risk procurement procedures and policies guarantee that the latest state-of-the-art attainable will be incorporated in the end product when it is delivered to the forces. These policies also carry with them the greatest prospects for waste, failures, stretchouts, overruns on cost, and other politically undesirable characteristics. Low-risk procurement procedures and policies, conversely, minimize the prospects of running into these politically undesirable developments, but inherently insure that the end product will be of lower performance--less technologically advanced--than would otherwise be possible.

The high-risk road is the one in which the best scientific talent is consulted with respect to what they <u>think</u> they can achieve in the way of technological progress by a given date. This goal is then accepted by DOD, the military, and Congress in terms of a complete end product, or weapon system. It is funded as such, and all concerned work to achieve it. Since what even the nation's best brains <u>think</u> can be done is at best an educated guess, this road has slippages, pitfalls, possible failures, and overruns built into it. But when the new system is finally built it is clearly the technologically most advanced system possible. This approach was practiced in the 1950s by the United States, and gave us such systems as Atlas, Minuteman, Polaris, etc.

The low-risk road seeks to minimize waste, overruns, failures, and the uncertain budget requirements associated with the high-risk road. This is achieved by decoupling the basic and exploratory research efforts and sometimes advanced development from systems engineering and production. The concept as enunciated under the McNamara regime was to get all science and technology in hand before authorizing weapon development and procurement. With all technology proven out and tested, the prospects of the weapon system development being successful, and on schedule both budget and timewise,

are greatly enhanced. BUT, a price is paid for this. If all technology is in hand when the advanced development, engineering, and procurement phases are started, and if these phases take from two to five years, the end product will be in effect two to five years technologically obsolete almost of necessity since no technology, or breakthroughs, that come "in hand" after the start of weaponization--that is, during the two to five year period before delivery--will appear in the end product except as a retrofit.

In the 1950s the United States followed the high-risk route. We had the most advanced weapon systems, missiles, electronics, radars, in the world at the time each was first delivered. We also suffered a great deal of criticism in the management and budget area for waste and instability. In the 1960s when the low-risk policies set forth in DOD 3200.9 required that ALL science and technology be in hand, before even asking for a new system development, the so-called "building block" program was adopted to pursue the early phases of research independently of weapons goals. These procedures achieved the desired improvements in the DOD management image but, according to some observers of R&D activities, cost the United States its technological leadership in many areas vis-a-vis the USSR. Had we continued the high-risk approach during the 1960s, our forces today might have had lightweight tanks and aircraft made largely of boron or carbon fiber materials, glide boost strategic systems like Dynasoar, satellite-based ABMs, and possibly even operational laser weapons. All of these would have been far superior to anything the Soviets could have fielded in the same timeframe since they have not been able to do so as yet even though, as far as we know, they still pursue the high-risk approach.

During the last few years the United States has adopted a middle-of-the-road approach to procurement that appears to lie somewhere between the high and low risk roads. The Total Package Procurement Program (TPPP) introduced for the C5 development as the final refinement in the low-risk road put so much leadtime between its fixed cost bids--with their attendant necessity that the bidder know all S&T is in hand and guess at such factors as inflation for years in advance--that it resulted in creating more management problems than it solved. Out of this failure DOD derived the present approach

which retains a separate technological base effort for the early phases of R&D but allows for some flexibility in regard to the amount of science and technology that must be in hand, and proven out, before proceeding towards a new weapon goal. Some aspects of high-risk such as concurrency in procurement and research spending are still rarely allowed. Competitive prototypes are funded, however, and technological advances can be introduced into the procurement phase once a selection has been made since procurement is subject to separate contracts.

These approaches to new weapons procurement have different impacts on our ability to orient our R&D efforts not only towards specific end products but also towards defensive versus offensive capabilities.

The high-risk road, by starting with the end product as a goal and forcing the state-of-the-art to achieve it, obviously allows one to select whether the end product pursued will be a primarily defensive or offensive system at the beginning of the R&D cycle.

The low-risk road, by funding the early phases of research independently of the end products desired, does not permit effective control over the extent to which findings of the resulting technology--or building block--efforts will contribute to offensive versus defensive systems. The technological base effort thus becomes a broad-based R&D effort that pursues all promising technologies and seeks to surface, and prove out, advances in the state-of-the-art that the planners can subsequently select from in proposing and developing new weapon systems. The choice of systems to be built, along with whether they are mainly offensive or defensive, is thus moved forward in the development cycle to the advanced development or engineering phase. Flexibility is also reduced, in that the tendency will always be to push forward with those products of the technological base programs that show the best prospects for improved operational capabilities in any area or for any element of the forces. Relative emphasis then becomes a random proposition.

- Under the technological base approach to the early phases of R&D, the best way to assure an adequately diversified, offensive versus defensive, weapons development effort is to assure an adequate, broad, and all-inclusive technological base effort from which diversified new capabilities can be selected for production to reflect operational requirements and/or lessons learned in the near term.

5. <u>On Offensive Versus Defensive RDT&E Orientation</u>

In order to determine whether the current U.S. RDT&E programs are properly oriented, as between the offensive and defensive, we have to first determine whether the weapon systems and support capabilities that these programs seek to replace or improve upon are primarily offensive or defensive. In the Strategic Force arena this can be done more readily than in the arena of "tactical" or General Purpose Forces.

Broadly speaking, strategic delivery systems are offensive whereas territorial protection systems, such as ABMs, air defense radars and guns, and submarine barriers are categorized as defensive systems.

Most tactical warfare systems and capabilities are dual purpose. Tanks are used on both the defensive and the offensive. Fighter aircraft systems, and their missiles, are defensive when on air defense tasks, but offensive when on counterair or interdiction tasks. Since most tactical weapons are dual purpose, many of their fire control, sighting, accuracy, and other features--that are the special targets of R&D improvement programs--must also be deemed to be dual purpose.

An overall scrutiny of the DOD Technology Base Programs, as set forth in the DOD RDT&E Statement to the 93rd Congress, suggests that there is no rational basis for categorizing the majority of these as being in support of either the offense or the defense. As discussed earlier in this paper, any selection under present procurement policies that would permit of bias in this regard would have to be made after the completion of technology base R&D, and more often than not after the completion of all phases

of R&D, with the possible exception of the test and engineering phases. In other words, orientation can only normally take place during the selection for production process, and even then it can only be done with respect to programs serving systems or capabilities that can themselves be clearly categorized as defensive or offensive.

The DOD RDT&E Statement to Congress referred to above gave a distribution of funding by mission areas. This identified only 8.2 percent of program funding as being in support of defense wide systems. Of the remainder, 25.3 percent was identified with strategic systems, and 34.9 percent with tactical systems. The rest of the RDT&E was shown as being in the support, management, or technology base efforts. Presumably the defense-wide systems are those associated with continental defense, and the tactical systems are the General Purpose Forces including both their offensive and defensive weapons and capabilities. A review of the tactical programs identifiable with General Purpose Force capabilities failed to indicate any apparent bias as between the offense and the defense, since the great majority of these appeared to advance some capabilities in both categories.

As a general proposition the identification and categgorization of R&D programs as between offensive and defensive capabilities can only be done in relation to the defense of the homeland, or of some fixed theatre with frontiers to be defended against an adjacent threat such as in NATO, NATO being in such a case the homeland of the Alliance. Conversely, expeditionary forces are not subject to categorization in this way since, almost by definition, it is not known in advance where, or in what roles, they will be used. They must therefore inherently possess both the offensive potential to attack and sufficient defensive potential to protect themselves from counterattack and survive in a variety of combat environments. On balance these forces--hence the R&D programs that support them--must emphasize mobility and offensive capabilities.

Even in the case of fixed overseas defensive commitments, such as in NATO, there would seem to be only limited justification for emphasizing defensive capabilities in the forces contributed by remote countries.

Territorial defense is primarily the host country's responsibility. In the event of aggressions the holding operations at the frontier will first be attempted by national forces, along with the establishment of minefields, barriers, and other purely defensive systems. U.S. forces based overseas, while temporarily committed to, say, a NATO task, are part of overall U.S. General Purpose Forces, hence of the expeditionary order of battle. They may be pulled out of NATO[1] to go to the Middle East, or any other area, at any time. They will probably not remain forever in NATO, or in any other foreign country. And, even when and where they are so committed, their local roles tend to favor reinforcement and counterattacks to help arrest invaders. These are essentially offensive tasks within the overall defensive mission. All of these points argue that the U.S. contribution to defensive alliances such as NATO must emphasize offensive force capabilities. Defensive emphasis, if any, would be found within the forces of the host nations.

There are historical exceptions to the above rules. The U.S. R&D effort in the mid-1960s to build up a linear, barrier, defense against North Vietnam can be pointed to as an example of defensive emphasis in General Purpose overseas U.S. forces. This was at best an exceptional circumstance and at worst a questionable decision. The length of the war, the inability of South Vietnam to cope with its own territorial defenses, and political decisions that precluded defending the country by conducting an offensive against the north created a situation in which the barrier approach--if U.S. technology could make it work--was about the only option left. After the expenditure of many man-hours of R&D on attempts to develop an effective barrier, the effort--and the associated diversion of U.S. R&D to this defensive plan--must in retrospect be viewed as either unachievable or a technical failure. Whatever the case it hardly argues for repetition or for any basic change in the offensive orientation of General Purpose Forces.

---

1 DOD FY75, <u>op. cit.</u>, p. 3-8: "The sum of weapons we develop must be aimed at many different kinds of conflicts, etc..."

The situation in the continental United States, and in such countries as Germany, Turkey or Israel, is different Here we are dealing with a need for national territorial defense on land from the onset of hostilities. Nonaggressor nations having frontiers in common with potential aggressor nations must emphasize defenses in order to be able to hold back an attack long enough to obtain reinforcements and even permit consideration of counteroffensive operations. The United States is not in this situation today, nor is it likely to be in the foreseeable future. In the United States, continental defense requirements at the outset of hostilities are largely limited to defending against air or missile threats. There is no primary role for General Purpose Forces in this effort, hence these forces do not need to emphasize in-place defensive capabilities. In most cases, U.S. General Purpose Forces will have to move (deploy) before fighting. This means that such R&D as can be usefully oriented to their support should emphasize improved mobility and the prospects of initial operations of an offensive nature in remote areas.

- U.S. General Purpose Forces, including those deployed in peacetime overseas in accordance with treaty agreements, should emphasize offensive combat capabilities. This results from a lack of requirements for these forces in a continental defense role, due to geography, and a high probable requirement that their initial overseas tasks will be reinforcing in the face of opposition and counterattacking.

If the above conclusion is correct, equal emphasis on defensive and offensive R&D programs in support of General Purpose Forces would not be logical. While an appropriate balance must be maintained, and adequate defensive capabilities provided to ensure force survival in the theatre, the emphasis should be on offensive battlefield capabilities. Any review of the balance would have to take this into account.

E. Summary of Findings

The purpose of the above analysis was to provide in convenient summary form a basis for responding to any questions that might be raised with respect to the orientation of U.S. R&D efforts vis-a-vis offensive versus defensive weapons and support systems in the General Purpose Forces.

The principal problem presented by any such questions stems, first, from the difficulty, if not near impossibility, of relating most R&D programs directly to offensive versus defensive capabilities, particularly in the tactical force area; and, second, from the fact that the "base line" from which any imbalance should be measured must first be determined. An even distribution of R&D effort as between offensive and defensive capabilities would be both arbitrary and illogical in light of U.S. geography, force commitments, overall strategic concepts, and national security objectives. In brief, the optimum emphasis is not 50/50 to start with!

Our discussion of the principal factors that will determine the answers to the above problem suggests that a complete explanation of the question of relative emphasis, as between R&D programs and offensive and defensive force capabilities, requires--a priori--an understanding of the major constraints that inherently bias U.S. defense programs. The findings set forth below are therefore grouped under these two headings since some of the General Findings which relate to these constraints, while essential to the purpose of this paper, may also be pertinent to other sections of the overall study.

1. <u>Findings on Offensive Versus Defensive Emphasis</u>

The majority of U.S. R&D efforts cannot be identified with advancing either offensive or defensive capabilities, particularly in the General Purpose Force area. This is due primarily to the fact that most R&D programs will serve to advance both capabilities, hence they make a dual contribution. The long leadtime in R&D programs, and the procedures and policies in vogue today, both contribute to decoupling technology base R&D programs from specific weapon system developments. This also contributes to this conclusion.

A scrutiny of the R&D programs set forth in DOD RDT&E presentation to the 93rd Congress for the FY75 budget indicates no identifiable bias in favor of offensive or defensive force capabilities, nor did such a scrutiny suggest any way to accurately measure such bias if it did exist due to the factors listed in the first finding above. In brief, we looked at it, we

saw no indication of mal orientation, but we are not sure how we would recognize mal orientation if it did exist!

A balanced U.S. RDT&E effort--if assumed to be an optimum balance for U.S. security purposes--would not logically favor the offensive and defensive equally. The geographical situation of the United States vis-a-vis potential threats, and our National Security Concepts and Policies, inherently establish a requirement for predominantly offensive force capabilities which presumably should be reflected in U.S. RDT&E programs and priorities:

- Having no common frontiers with major enemies we have a minimum of "holding from the onset" requirements, hence D-day defense capability needs.
- Our General Purpose Forces have primarily an expeditionary role, wherein reinforcement of allies, landing in the face of opposition, and counterattack operations are more likely missions than holding territory.
- Peacetime U.S. forces deployed to overseas defensive tasks, as in NATO, cannot be considered permanent and must be prepared for redeployments at any time; hence, in light of R&D leadtimes, such essentially temporary commitments should not be permitted to unduly influence overall RDT&E orientation.

The favoring of offensive or defensive force capabilities, on the basis of "lessons learned" or of "changing operational requirements" can only be done, in timely fashion, by being selective as among those new technologies and new weapons ready to go into production and deployment. At this point in the RDT&E cycle much of the R&D work is complete and in hand. This suggests that the problem of emphasis on offensive versus defensive capabilities in the area of R&D is one of system selection for deployment rather than one of RDT orientation. Some overlap, if there is any, might be found in the systems engineering area.

2. Findings on Considerations that Affect RDT&E Orientation

U.S. RDT&E Program orientation is, and should properly be, determined largely by (not in order of priority):

- Technological possibilities that offer the prospects of providing cost effective new operational capabilities, either defensive or offensive
- The U.S. geological position vis-a-vis potential threats
- Long-term U.S. National Strategic Concepts and Policies
- Trends in the role, and potential future contribution, of technology to the outcome of battles and wars
- The technological threat, including breakthrough possibilities on the part of potential enemies
- The anticipated nature and location of conflicts that the United States might become involved in (conventional vs. atomic, limited vs. global, arctic vs. desert, etc.).

U.S. technological base programs should not be influenced or limited by treaty, moral, arms control, or other similar and possibly nonpermanent, manmade constraints. Due to the long leadtimes involved in developing new capabilities in the present era of advanced technology, and to the uncertainty of perpetual adherence to such manmade--essentially political--constraints, these should only be applied to the RDT&E cycle at the point of decision to produce and deploy affected capabilities. They should never be permitted to prevent the pursuit of basic or exploratory research in the areas concerned. The United States should at all times get and keep in hand all the science and technology necessary to react to the identification or appearance of any major new weapon whether it is currently prohibited from use or not.

Defense technology, first in the form of the atomic developments and more recently in the form of greatly improved conventional weapon "kill" capabilities, is changing the relative importance of quantity of forces--mass--to the outcome of battles and wars. As a one-shot one-kill optimum

is approached, firepower delivery systems and manpower requirements decline in terms of what is needed to do any fixed task. Other important consequences of this technological trend are:

- Growing importance to the outcome of conflicts of the weapons and forces in being at the onset
- Decreasing importance to the outcome of conflicts of national mobilization capabilities
- Increased decisiveness of the initial phase of hostilities, and the associated decreasing likelihood of long wars of attrition. (Vietnam contradicts this finding ONLY because of the political limitations imposed in that war on the fullest exploitation of the products of technology)
- Increased prospects for smaller nations to become self-sufficient in deterrence and defense by relying on technology rather than mass
- Prospects for reduced costs of effective levels of forces and weapons, particularly in nations in which manpower is a major cost factor.

In brief, technology is beginning to provide in new conventional weaponry for general purpose forces the benefits of automation and productivity that it conferred on our strategic posture with the advent of atomic munitions in the 1940s and 1950s.

As the outcome of wars becomes more dependent on relative firepower capabilities--resulting from advanced technology efforts--the importance of technological intelligence increases. The old saying in wrestling that "for every guard there is a guard against it" also applies to military innovations PROVIDED one has the time necessary to devise and deploy the "guard against it." The decisiveness of the early phases of future conflicts that are waged with advanced weapon systems detracts from the prospects of timely reaction to enemy innovations AFTER the start of hostilities. The long leadtime required in today's R&D efforts on new developments and counter-developments also detracts from quick reaction possibilities. Both these considerations argue for early intelligence on enemy innovations.

Technological intelligence is a function not only of collection of information on what our enemies are seeking to develop in the way of new military capabilities, but also of being able to recognize the indicators that point to these in timely fashion. Analysis and recognition of the early indicators of enemy R&D programs will depend to a great extent on the level of ongoing U.S. R&D, in like areas, underway at the time. This in turn argues for the broadest possible U.S. basic and exploratory research programs to include programs in fields which may at the moment appear to have no military value by virtue of treaties, agreements, or other manmade political constraints imposed on the use of the weapon systems they would otherwise advance.

The very latest weapon systems that the state-of-the-art in the world at any time can produce will be had first only by those nations that are willing to pursue high-risk RDT&E and weapon system procurement policies. These policies, which focus even basic research on the end product to be achieved, force the state-of-the-art towards preagreed goals and allow for a maximum of concurrency in research, development, test, engineering, and procurement actions. They are, however, costly in terms of failures, waste, cost overruns, and slippages. This is the approach that gave the United States such systems as Atlas, Polaris, Minuteman, and others that were years ahead in performance and technology of those fielded by the USSR in the same timeframe.

Attempts to maximize management efficiency and economy by pursuing low-risk development and procurement policies, such as were practiced in the early and mid 1960s, can result in technologically obsolescent, hence inferior, equipment to that provided enemy forces whose governments pursue the high-risk procurement route. This results from the fact that low-risk policies require that all science and technology be proved out and in hand before proceeding to engineering and production. Some even attempted to package R&D and early procurement under a single fixed cost bid. The net effect of this is to make it impossible for any technological advances that may be proved out during the two to five years of engineering and production to appear in the new systems except as retrofits. Likewise bidders faced

with fixed cost rather than cost plus contracts will take no chances of loss through slippage or failures by proposing innovations that they have not proved out beyond any question of doubt.

Present policies appear to be charting a middle course between high-risk and low-risk procurement. By decoupling the technological base programs from ultimate weapon systems procurement, and severely limiting concurrency in R&D and procurement actions, they reduce the prospects of criticism for systems failures, slippages, and overruns. On the other hand, DOD Directive 5000.1 is far less restrictive than were the Program Definition Phase requirements under DOD 3200.9. Funding competition under fly and buy policies; the DSARC review process that expedites program decisions; and possibly design-to-cost programs will reduce the extent of technological obsolescence at the time of delivery to the forces. Whether current approaches will provide U.S. forces equal or better equipment than that of the USSR will depend on whether the USSR--having caught up with us technologically--continues to pursue a high-risk route. Intelligence should keep Soviet policies in this regard continually under review.

The prospects of realizing breakthroughs important to defense, or of being able to respond in timely fashion to breakthroughs realized by others, depend to a large extent on the relative efforts being made in R&D and on the relative freedom from constraints that each side enjoys when it comes to pursuing potentially helpful lines of research. In an era in which technological innovations can prove to be decisive to the outcome of battles, no nation can afford to consistently maintain a position of technological inferiority.[1] Since it is far more difficult to measure enemy R&D activities than it is to count enemy forces in being, the only measure of the prospects of maintaining technological parity, if not superiority, is to be found in comparing the funds, manpower, and technical facilities provided for R&D. Published comparisons and official statements on the U.S. versus Soviet R&D efforts indicate that since 1968 U.S. funding has declined while the USSR

---

[1] Reflected in DOD FY75, op. cit., p. 6-2, para. 6.2.

has steadily increased its support of research and development. Antidefense attitudes have also reduced the numbers of scientists in Universities that are addressing defense-related problems in recent years. Finally the low-risk DOD procurement policies of the 1960s, and diversion of resources to Vietnam, have combined to deny funding for some of the more advanced technical facilities--such as True Temperature Wind Tunnels--that the Soviets are understood to have. Unless these trends are reversed the long-term prospects are for the Soviet Union acquiring technological superiority, if there is any relationship between efforts and results!

No nation can pursue "responsive" RDT&E policies and hope to maintain an adequate level of national security. Since "responsive R&D" means that the United States will not initiate new weapon development programs, or pursue new defense technologies, except in response to identified efforts in these areas by others, such a policy can only lead to technological inferiority in all areas due to a combination of leadtime and difficulty in obtaining intelligence in this area. The argument, therefore, that aggressive R&D undertaken independently of identified new threats is provocative of arms races--while possibly true--must be rejected on the grounds that the alternative is technological and eventual military inferiority. This is an important message that must be clearly conveyed at all times.

ALTERNATIVE GUIDELINES FOR RDT&E ACTIVITIES

by

F. Trinkle

ALTERNATIVE GUIDELINES FOR RDT&E ACTIVITIES

SUMMARY

Although the analysis presented is not a comprehensive one, several concluding observations can be drawn. First, the adoption by the United States of a measured response R&D strategy appears to be a desirable choice. Guidelines for the implementation of this strategy are relatable to potential deployment classes. The implementation of such a strategy offers distinctive prospects for influencing Soviet R&D activities. Should the strategy be jointly adopted by both the United States and the Soviet Union, prospects for achieving comprehensive controls over the quality of strategic forces could be enhanced; moreover, prospects for reaching potential agreement covering nonstrategic forces could also be enhanced.

U.S. strategy of technological superiority, although a desirable strategy from the U.S. viewpoint, cannot but compel the Soviet Union to allocate increasing expenditures to military R&D so that the technological gap presently existing is not exacerbated. Unless there is restraint shown in the Predeployment System process, prospects for controls on the qualitative character of forces are less than fully certain. Should both the United States and the Soviet Union strive for technologically superior advanced systems, it is highly unlikely that qualitative restraints on future force deployment could be achieved.

Although favored by some persons in the scientific community, a unilateral move by the United States to significantly curtail its military R&D activities could have grave consequences, unless simultaneously adopted by the Soviet Union. In the past, some persons have argued that the research component (research and exploratory development) of R&D fuels the arms race between the United States and the USSR. Clearly, this is

not the case as an examination of the activities included in the two categories will show. Neither the Soviet Union nor the United States has a monopoly on scientific talents generally associated with these activities. The argument that the development component (advanced development and engineering development) is potentially destabilizing has some merit, especially if both superpowers elected R&D strategies emphasizing technological superiority. However, systems in the predeployment stage require a significant level of resources, talented teams of engineers and others, and, because of the long development cycle, a commitment long enough to indicate the potential worth of the program. Systems do not automatically pass from the predeployment stage to a deployment stage. Within the United States, major systems have been canceled prior to deployment (SKYBOLT, MMRBM, B-70, and MOL, for example), and undoubtedly cancellation of systems has also occurred in the Soviet Union.

The issue of what level of resource allocation is proper for military R&D is an exceedingly difficult one. Even if reliable information were available, it would not be appropriate to have the expenditures for military R&D within the United States and the Soviet Union closely matched, nor would it be meaningful to match such expenditures in selected R&D activities. An R&D strategy based on measured response concepts could contribute to controlled R&D expenditures; more importantly, it offers prospects for influencing such expenditures within the two countries.

Finally, selected issues concerning the Weapons Systems Acquisition forces were also developed. That process should be related to alternative R&D strategy choices. The task of designing an acquisition process fully supportive of a preferred R&D strategy choice, however, remains to be accomplished. Although exceedingly difficult, it is of utmost importance.

ALTERNATIVE GUIDELINES FOR RDT&E ACTIVITIES

A. Nature of the Issue

Whether the overarching characterization of the U.S. research and development program by technological superiority was basically a bargaining chip designed to achieve agreement with the Soviet Union on SALT I and SALT II issues and to a lesser extent in upcoming MBFR issues is uncertain. It is clear, however, that the over-hoped-for agreements on qualitative characteristics of strategic forces deployed by both the United States and the Soviet Union were not achieved as part of the conceptual breakthrough at Vladivostok. Instead a cap on the number of strategic forces, including long-range bombers, as well as on the number of missiles which can be MIRVed, was obtained. These ceilings are envisioned to be in force through 1984. Essential equivalence in numbers but not in potential capabilities was achieved. And although at present the United States enjoys a distinctive qualitative edge, this edge cannot be assured to remain with the United States in the future.

To be certain, less than one-fourth of the total annual RDT&E expenditures within the United States are directly or indirectly attributed to potentially deployable strategic forces. Yet these forces, in large part, provided the rationale in the past for the concept of technological superiority.

Attitudes concerning technological superiority appear to have changed. Consider the following statements:

> If the United States ever decides we cannot afford to maintain technological superiority, then we must be willing to accept the status of a second-rate power. (Melvin R. Laird)[1]

[1] Final Report to the Congress of Secretary of Defense, p. 6 (8 January 1973).

> We need an adequate, long-term level of R&D funding if we are to avoid technological surprises and maintain a reasonable margin of technological superiority in key areas important to the overall military balance.
> (Elliot L. Richardson)[1]

> During the next few years, we must search for and assess the best R&D, weapons acquisition, and other strategies for the long haul. In doing so, we must ask such questions as how we can most efficiently compete with our major potential opponents, and what constitutes our own major strengths and weaknesses.
> (James R. Schlesinger)[2]

The latter two statements clearly reflect a shift in official thinking concerning appropriate guidelines for research and development activities. Secretary Schlesinger's statement shows that the issue of preferred R&D guidelines is not easily resolvable.

The purpose of this paper is to explore alternative guidelines for R&D activities, and to assess their potential utility in terms of a generalized U.S.-Soviet interaction analysis. By no means is this paper definitive. Hopefully, however, it should provide insight into the issues considered.

A fundamental premise of this paper is that an overarching characterization of U.S. R&D activities is not sufficient, unless spelled out in broad operational terms. The approach taken here consists of specifying guidelines for the major categories within R&D as they relate to potential DOD military missions.

B. Overview of U.S. RDT&E Activities

Since the 1960s, six major categories comprise RDT&E activities:

---

[1] Annual Defense Report FY 1974, p. 14 (28 March 1973).

[2] Annual Defense Report FY 1975, p. 15 (4 March 1974).

- Research--efforts directed toward the solution of basic problems, relevant to long-term national security, in the disciplines of physical, chemical, biological, engineering, medical, behavioral and social science;
- Exploratory Development--effort directed toward the application of research results and the development of materials, components, devices and subsystems useful to new military weapons and equipment;
- Advanced Development--efforts directed toward producing experimental hardware for feasibility testing to determine its suitability for military use before proceeding with the design and engineering for actual service use;
- Engineering Development--efforts directed toward designing weapon systems or equipment specifically engineered for use of employment, but not approved for production and deployment;
- Operational Systems Development--efforts directed toward the development, test, evaluation and design improvement of weapon systems or equipment which have been approved for production and deployment; and
- Management and Support--involves the operations of test ranges, some of the in-house laboratories, and the general R&D indirect support.

Research, Exploratory Development, and a small part of Advanced Development comprise the technological base. Since FY 1965, total allocations have been steadily reduced from about $1.5 billion to $1.3 billion in FY 1971, and subsequently increased to about $1.5 billion in FY 1975. In real terms, correcting for inflation, the reduction is notable and has troubled R&D planners.

Activities within Advanced Development, Engineering Development, and Operational Systems Development comprise about 70 percent of R&D allocations. These activities are directly relatable to DOD military missions.

Management and Support have been funded at a nearly constant level between FY 1965 and FY 1975, but in real terms the share allocated to this category has also declined. Few of these activities are directly relatable to DOD military missions.

C. Framework for Specifying R&D Guidelines

Within the framework of the analysis presented here, the six major categories of RDT&E are regrouped as follows:

- Technological Foundation primarily consists of activities comprising the categories of Research and Exploratory Development;
- Predeployment Systems consists of the programs under the categories of Advanced Development and Engineering Development;
- Operational Performance Improvements consists of tests and evaluations of systems and identified with the category of Operational Systems Development.

The category Management and Support is excluded from further analysis, primarily because of the indirect, supportive nature of these activities and because conventional management principles seem most appropriate.

Again, within the framework of the analysis, since it is judged important to relate the various RDT&E activities (to the extent possible) to potential military missions, several classes of military missions are used. These are:

- Strategic Nuclear Deterrence consists of those Predeployment systems (including strategic C^3 and surveillance systems) viewed as having a primary nuclear deterrent value (e.g., Trident, B-1);
- Theater Nuclear Deterrence consists of those Predeployment systems (including tactical C^3 and surveillance systems) viewed as having a tactical nuclear role and war-fighting capability (e.g., Pershing, nuclear ADMs);
- Land Battle and Air Control consists of those Predeployment systems (including battlefield status systems) viewed as having a conventional or unconventional war-fighting capability (e.g., Main Battle Tank, F-14); and
- Rapid Deployment and Sea Control consists of those Predeployment systems viewed as theater support mobilization, air lift and seatransport capabilities, and conventional ASW.

Although further characterizations of potential military missions could be required for a comprehensive analysis, the use of these classes will illustrate alternative R&D guidelines that might be desirable and worthy of consideration.

When the three R&D classes are combined with the four military mission classes (as shown in Figure 1), a framework for evaluating R&D guidelines results. Within this framework, an R&D strategy choice consists of specifying guidelines (to the extent possible) for the conduct of activities relevant to the various joint combinations shown.

D. Alternative R&D Guidelines

Under the concept of technological superiority, the Technological Foundation activities were governed by a level of effort guidelines, whereas Predeployment Systems and Operational Performance Improvements were governed by the superiority guidelines independent of the potential military mission classes as shown in Figure 2. To a large extent, the technological superiority concept had as its rationale arguments concerned with hedging against uncertainty, hedging against the failure of SALT, and safeguarding against the opponent's technological breakthroughs (especially in light of the long leadtimes of sophisticated weapon systems). The prospects of achieving such superiority across the spectrum of capabilities against a determined opponent could not be assured, especially since the required resource allocations were not forthcoming.

More recently the concept of technological balance has been put forward by defense planners as an overarching concept governing R&D activities. Although not precisely articulated, the technological balance concept could be interpreted within Richardson's previously quoted statement. The Technological Foundation activities could be governed by guidelines incorporating a notion of a reasonable effort which avoids technological surprises. One difficulty with the term <u>technological surprise</u> is that surprise, by definition, cannot be anticipated. Once surfaced, the issue

Figure 1

FRAMEWORK FOR SPECIFYING R&D GUIDELINES: RELATING TO POTENTIAL MILITARY MISSIONS

Military Mission / R&D Classes	Strategic Nuclear	Theater Nuclear Deterrence	Land Battle & Air Control	Rapid Deployment & Sea Control
Technological Foundation				
Predeployment System				
Operational Performance Improvements				

Figure 2

GUIDELINES UNDER A TECHNOLOGICAL SUPERIORITY R&D STRATEGY

Military Missions / R&D Classes	Strategic Nuclear Deterrence	Tactical Nuclear Deterrence	Land Battle & Air Control	Rapid Deployment & Sea Control
Technological Foundation	← Level of Effort →			
Predeployment System	← Technological Superiority (a hedging strategy) →			
Operational Performance Improvements	← Technological Superiority →			

becomes one of leadtime required to achieve comparable capabilities. Generally, leadtimes are such that an exploitable advantage does not unequivocably lie with either of the superpowers. Technological balance as applied to Predeployment Systems and Operational Performance Improvements could be interpreted as maintaining a reasonable margin of technological superiority in key areas. The issue remains what are the key areas as they relate to potential military missions. Contrasted with the concept of technological superiority, the concept of technological balance (as stated here) could afford prospects for dampening an intense, potential technological competition between the superpowers in an era of detente. Figure 3 characterizes the R&D strategy.

Neither of these two overacting concepts--technological superiority and technological balance--appears to provide sufficient guidelines characterizing R&D activities. Neither concept per se allows an evaluation of its ultimate disability, especially when assessed in terms of likely interactive consequences between the United States and the Soviet Union.

As an alternative to a technological superiority or a technological balance R&D strategy, a concept of a measured response R&D strategy will be developed. It is believed that such a strategy would provide incentives for continued military force agreement between the United States and the Soviet Union. The concept also recognizes that Soviets are no longer in a distinctively inferior technological position vis-a-vis the United States; indeed, in some areas they have achieved a position of technological advantage. Moreover, the concept is based on a premise that prospects for achieving significant future agreement are importantly influenced through a controlled R&D strategy.

Figure 4 highlights guidelines which would govern R&D activities under a measured response R&D strategy. Under this strategy, guidelines concerned with innovative, broadly based research and exploratory development govern the resource allocations to Technological Foundation. The

Figure 3

GUIDELINES UNDER A TECHNOLOGICAL BALANCE R&D STRATEGY

R&D Classes \ Military Mission	Nuclear Deterrence	Nuclear Deterrence	Land Battle & Air Control	Rapid Deployment & Sea Control
Technological Foundation	---- Efforts Designed to Avoid Technological Surprises -------			
Predeployment Systems	----- Reasonable Margin of Technological Superiority -------			
Operational Performance Improvements	----- Reasonable Margin of Technological Superiority -------			

Figure 4

GUIDELINES UNDER A MEASURED RESPONSE R&D STRATEGY

R&D Classes \ Military Mission	Strategic Nuclear Deterrence	Tactical Nuclear Deterrence	Land Battle & Air Control	Rapid Deployment & Sea Control
Technological Foundation	---------- Innovative, Broadly Based Research ------------ (Civilian Sector Transfers Facilitated)			
Predeployment System	Prudently timephased, qualitative equivalence	Maintenance of qualitative advantage	Affordable, selective qualitative & quantitative edge	Affordable, yet flexible, advantabe to project presence
Operational Performance Improvements	High Confidence, Dependability---		---Prudent, But Sufficient---	

major purpose here is to remain in the forefront in selected technological areas in which we always have had a comparative advantage. Emphasis would also be placed on assuring technological transfer of relevant results to the civilian sector as soon as such transfer is judged possible.

A major departure for existing R&D strategy occurs in guidelines underlying Predeployment Systems. Systems having potential deployments under the strategic nuclear deterrence missions are managed by a guideline characterized by prudently time-phased capabilities, striving for qualitative equivalences of perceived capabilities between the two superpowers. The rationale for this guideline rests on the observation that, if either power perceives itself to be in a position of technological inferiority as related to future deployed strategic forces, incentives for maintaining existing SALT I and II agreements or the search for further agreements could be weakened. Predeployment Systems relatable to tactical nuclear deterrence would be managed by a guideline characterized by the maintenance of qualitative advantage. Since the United States is unable to match Soviet capabilities in strictly quantitative terms, nor is such matching desirable, future U.S. tactical nuclear forces should retain the qualitative advantage they now generally have in selected weapon systems. Under the land battle and air control mission, Predeployment Systems would be managed by a guideline characterized as an affordable, selective qualitative and quantitative edge to the extent possible. Close air support and conventional munitions are examples of systems in which the edge is judged in our favor. The current DOD policy of "high/low" capabilities complements this guideline in a significant manner. Finally, under the rapid deployment and sea control mission, Predeployment Systems would be managed by a guideline characterized as affordable, yet flexible, advantage to project U.S. presence overseas. Over time, U.S. overseas deployments can be expected to be reduced either through balance-of-trade difficulties or through agreements resulting from MBFR negotiations. Alliances will remain vital to our national security interest, and consequently, over time a credible rapid deployment and sea control mission will remain important. Again, a "high/low" capabilities mix policy importantly contributes to this mission.

Finally, for strategic and tactical nuclear deterrence missions, the guideline governing Operational Performance Improvements is characterized as high-confidence dependability; whereas for land battle and air control as well as rapid deployment and sea control missions, the guideline is characterized as prudent, but sufficient. If the pace of force modernization can be controlled, especially strategic force modernization, and paced with Soviet force modernization, the requirement for testing and evaluation could become less intensive. Also, if in the development cycle the principle of designing against low probability but catastrophic failure in a hostile environment is incorporated, then the requirement for additional testing to "verify quick fixes" could be reduced.

Other R&D guidelines are certainly conceivable. They could consist of a mixture of guidelines considered here, and in the final analysis they may turn out to be more desirable. Whatever the alternative considered, a framework such as that deployed here should prove useful in evaluating specific R&D strategies.

The ultimate desirability of any R&D strategy choice is importantly influenced by the R&D strategy selected by the opponent. However, before analyzing such potential interaction, some issues concerning force modernization and weapon system acquisition associated with alternative R&D strategy guidelines are developed.

E. Some Force Modernization and System Acquisition Issues

Over the last several years, notable insights into force modernization issues as well as stable improvements in weapon systems acquisition have been achieved within DOD. "Extended planning annexes" identifying long-haul maintenance requirements for new equipment, improved independent cost analysis capabilities, policies of "design-to-cost" and "fly-before-buy," mission concepts and development concept papers, the Defense Systems Acquisition Review Council, as well as the "Hi-Low" force mix concept, have contributed to improving the acquisitions and modernization

process. Notwithstanding these improvements, there remain several areas in which additional improvements are desirable, depending on the R&D strategy choice.

1. "Hi-Low" Force Mix Concept

As presently articulated, for a particular mission, the concept envisions a small number of high-performance, sophisticated weapons capable of coping with the maximum enemy threat and a large number of less sophisticated and less expensive but capable weapons for continuing the lower capability enemy threats. To be certain, assessment of opponent capabilities is vital for R&D planning. However, the principle of maximum enemy threat without regard to likelihood of achievement, time phasing constraints, unforeseen technology slippage, etc., cannot but result in attributing to an opponent capabilities in excess of those realistically achievable within the United States. If the principle had stressed threats somewhat greater than realistically expected, weapons acquisition might become more controllable. In addition to the ongoing net assessment activities within DOD, a function concurred with a relatively detailed, but realistic, assessment of Soviet predeployment systems and operational performance improvements activities from a Soviet viewpoint in light of such U.S. activities could prove extremely useful under all U.S. R&D strategy choices, but more so under a measured defense strategy choice.

2. Controlling Systems Sophistication

Increasing attempts are being made to clearly specify design essentials and to tie postcontract design changes to dollar availability. A certain number of design changes are unforeseeable and unavoidable. This issue is primarily related to the high element of the "hi-low" force mix concept, but it is also reflected in the low threat of the concept. While the use of commercial standards and practices, off-the-shelf or standardized subsystems, help alleviate the problems, additional steps seem to be required. Perhaps postcontract financial rewards, for keeping

design changes to a minimum while controlling sophistication without essential performances, are warranted.

3. Controlling the Maintenance Interval

Increasing evidence indicates that Soviet equipment and systems are more rugged than their U.S. counterpart, and require less maintenance. Ruggedness and simplicity of design also appear to be stressed in Soviet predeployment systems. These considerations should take on greater importance in U.S. R&D planning. If achieved, greater life expectancy of U.S. systems should also result.

4. Achieving Cost Controls

The issue of cost overruns is a problem that appears to defy solution. With the establishment of the Cost Analysis Improvement Group within OSD and similar staffs within the services, further attempts to obtain reasonable cost estimates have been made. While parametric cost estimates allow an independent review of cost reasonableness, they do not necessarily identity the critical areas in which cost constraints are likely to be exceeded. What appears to be required is an "early warning cost flagging" system for use by both the contractor and the program manager so that timely design-cost resolutions are possible. An increase in contractor cost control estimation capability, as opposed to a costing capability, needs to be implemented.

F. Interactions Among R&D Strategy Choices

The discussion of likely interactions among R&D strategy choices is limited to various combinations of the alternatives developed here, and further limited to broad consequences that might be expected. An understanding of these interactions is important, and is vital in assessing alternative R&D choices. Such evaluation is not static; reevaluation is important as additional information concerning the actions of the two

superpowers becomes available. It is also reasonable to expect that concepts pertinent to the various combinations developed would undergo modification as the dialogue between the United States and the Soviet Union continues. In the analysis that follows it is assumed that both the United States and the Soviet Union have as options that selection of either of the three R&D strategies previously discussed, and several cases of likely interactions are developed.

Case 1. Both the United States and the Soviet Union select R&D strategies emphasizing technological superiority.

Under this strategy selection, the R&D activities within both countries can be expected to intensify with the Soviets allocating increasing funds in the determination to overtake the United States in predeployment systems technology, while simultaneously the United States would be determined not to let this happen. Such a strategy selection would augur ill for attempts to thwart the deployment of increasingly sophisticated weapon systems; moreover, such activities could also make more difficult future attempts (beyond SALT II) to control the qualitative character of deployed strategic forces. Intensive competition across the spectrum of future deployed forces could also be expected. This strategy matching cannot be viable over time. One power is bound to perceive itself in a militarily, technologically inferior position, and destabilizing influences could come into existence. This strategy selection would present hurdles (perhaps insurmountable) to continued bargaining between the United States and the Soviet Union.

Case 2. The United States selects a measured response R&D strategy, while the Soviet Union strives for technological superiority.

A critical observation is apparent. This strategy matching is not symmetrical; that is, the Soviet Union selects a measured response R&D strategy while the United States selects a technological superiority strategy. The observation is based on the premise that

presently the United States has the technological advantage in almost all military R&D activities. Consequently, a Soviet measured response strategy under the conditions stated is not a meaningful choice for the USSR. Returning to the initial strategy match, the United States under its strategy of measured response would be in a position to deny to the Soviets prospects for achieving technological superiority. Even if the Soviets were to strive for technological superiority as an interim strategy, U.S. efforts could undeniably convince them that such superiority is unattainable. The essential difference between Case 2 and Case 1 lies in U.S. attempts to directly influence Soviet R&D activities through restraint in U.S. R&D activities. Unlike Case 1, the Soviets would not feel compelled to technologically overtake the United States. Prospects for future agreements on force modernization issues could be painstakingly slow, but nevertheless still possible.

Case 3. The United States adopts a technological balance R&D strategy, while the Soviet Union continues its extensive R&D program.

This strategy match could resemble Case 2 to a certain extent. It differs from Case 2 in one important element. Unless the technological balance strategy is used in an attempt to directly influence Soviet R&D choices, the Soviets could doggedly strive for a portion of technological superiority. More likely, the Soviets could use this opportunity to at least close the technological gap in areas they consider important. Should they perceive that they have achieved equivalence in all R&D activities, they might be willing to subsequently contain their R&D activities. It is highly likely, however, that a U.S. technological balance strategy can be used to deny to the Soviets a position of technological superiority. While the degree of R&D competition could be lessened, this strategy match is likely to approximate the consequences discussed in Case 1.

Case 4. Both the United States and the Soviet Union select measured response R&D strategies.

Under this strategy, resolution of issues concerning force moderation can be more readily accomplished. There appear to be two paths toward this case. Such a strategy match could evolve from Case 2, although the time required for its implementation would be relatively long. Alternatively, such a strategy match could be a direct result of future direct negotiation; and, while such negotiations are undoubtedly complex, no insurmountable hurdles are apparent. In either event the joint adoption of measured response R&D strategies would add an additional element of stability allowing additional force agreements to be reached. The adoption of this strategy could result in a degree of competition as to the quality of conventional forces. Such competition, however, need not be destabilizing, since conventional forces have differing emphases in the national security policies of both countries.

G. Concluding Observations

Although the analysis presented is not a comprehensive one, several concluding observations can be drawn. First, the adoption by the United States of a measured response R&D strategy appears to be a desirable choice. Guidelines for the implementation of this strategy are relatable to potential deployment classes. The implementation of such a strategy offers distinctive prospects for influencing Soviet R&D activities. Should the strategy be jointly adopted by both the United States and the Soviet Union, prospects for achieving comprehensive controls over the quality of strategic forces could be enhanced; moreover, prospects for reaching potential agreement covering nonstrategic forces could also be enhanced.

A U.S. strategy of technological superiority, although a desirable strategy from the U.S. viewpoint, cannot but compel the Soviet Union to allocate increasing expenditures to military R&D so that the technological gap presently existing is not exacerbated. Unless there is restraint shown in the Predeployment System process, prospects for controls on the qualitative character of forces are less than fully certain. Should both

the United States and the Soviet Union strive for technologically superior advanced systems, it is highly unlikely that qualitative restraints on future force deployment could be achieved.

Although favored by some persons in the scientific community, a unilateral move by the United States to significantly curtail its military R&D activities could have grave consequences, unless simultaneously adopted by the Soviet Union. In the past, some persons have argued that the research component (research and exploratory development) of R&D fuels the arms race between the United States and the USSR. Clearly, this is not the case as an examination of the activities included in the two categories will show. Neither the Soviet Union nor the United States has a monopoly on scientific talents generally associated with these activities. The argument that the development component (advanced development and engineering development) is potentially destabilizing has some merit, especially if both superpowers elected R&D strategies emphasizing technological superiority. However, systems in the predeployment stage require a significant level of resources, talented teams of engineers and others, and, because of the long development cycle, a commitment long enough to indicate the potential worth of the program. Systems do not automatically pass from the predeployment stage to a deployment stage. Within the United States, major systems have been canceled prior to deployment (SKYBOLT, MMRBM, B-70, and MOL, for example), and undoubtedly cancellation of systems has also occurred in the Soviet Union.

The issue of what level of resource allocation is proper for military R&D is an exceedingly difficult one. Even if reliable information were available, it would not be appropriate to have the expenditures for military R&D within the United States and the Soviet Union closely matched, nor would it be meaningful to match such expenditures in selected R&D activities. An R&D strategy based on measured response concepts could contribute to controlled R&D expenditures; more importantly, it offers prospects for influencing such expenditures within the two countries.

Finally, selected issues concerning the Weapons Systems Acquisition forces were also developed. That process should be related to alternative R&D strategy choices. The task of designing an acquisition process fully supportive of a preferred R&D strategy choice, however, remains to be accomplished. Although exceedingly difficult, it is of utmost importance.

INTERNATIONAL COOPERATION IN R&D: HOW CAN IT BE ACHIEVED?

by

R. C. Wakeford

INTERNATIONAL COOPERATION IN R&D--HOW CAN IT BE ACHIEVED?

SUMMARY

The economic conditions in both Europe and the U.S. have given renewed impetus to the drive for standardization through the medium of cooperative R&D. The major issues to be resolved are dominated by the need for joint R&D planning either within a revitalized and decisive NATO organization, or trilaterally with the U.S., UK, and W. Germany. R&D planning with these two allies promises to play an important role in the future as resource limitations and the realities of interdependence are further understood. Planning with the more modestly endowed R&D performers of Europe could be deferred until the principal partners had resolved differences.

Cooperative R&D planning, when appropriately juxtaposed with U.S. technological base and mission planning, could serve as a basis for the reformulation of domestic defense R&D plans. As a drive to both military force modernization and economy of effort, a rejuvenated cooperative R&D effort could revitalize the partnership from the base up, strengthen the strategic coupling and force planning activity of the alliance, and militate against the numerical superiority of Soviet forces. The need for a concerted effort to organize many of the R&D cooperative functions at the DOD level, and a full-time staff to implement existing policy, would do much to consolidate the present fractionated effort. Once established, the U.S. vehicle for cooperative planning could be used to stimulate comparable organizations within the alliance and improve the dialogue among the NATO nations. Thus, cooperative R&D planning coordinated or consolidated at the highest level of DOD could replace the ad-hoc efforts and, over the long term, provide a sound basis for compatible military, political, and economic strategies.

Requirements issues, particularly those involving degree of sophistication of weapons and equipments, have continued to cause difficulty to harmonizing needs, but the stark realities of the present economic environments are likely to provide an opportunity for alleviating the problem. Further efforts to define the differing levels of sophistication needed for U.S. weapons and equipments serving a global role, as against a more limited European combat scenario, are essential to obtaining resolution of differing R&D requirements. A modular approach to the specification of U.S. weapons and equipments, to facilitate an expansion of systems to serve a world role, offers some promise. The economic issues of R&D cooperation will yield to any sensible methodology that provides a quid-pro-quo solution. This can be accomplished by shared developmental work and production, or the equalizing of both aspects of the process across the Atlantic over a period of years.

Cooperation in the technology base area poses a minimal burden upon most nations in terms of manpower and defense expenditures. More formalized and frequent data exchanges based on the development of a common set of research and exploratory development objectives would do much to avoid wasteful duplication. Effective cooperative efforts during or at the close of the advanced development cycle are a key to future standardization. Once projects have entered engineering development, it becomes extremely difficult to negotiate change and consolidate requirements. The advanced development stage of R&D provides an appropriate pause in the progress toward systems deployment, and offers an opportunity for negotiating differences prior to the incurring of heavy cost commitments and inferred production.

Recent economic problems have been assessed to determine their impact upon the alliance; one result of this assessment is that a more compelling case can now be made for interdependence in the R&D field. The nations of Western Europe are a major source of scientific and technological advancement and as such are capable of making major R&D contributions to the common security. The R&D resources of the British Aircraft Corporation, Messerschmitt-Boelkow-Blohm, and Lockheed Aircraft are a common

resource of the alliance; what is missing are appropriately staffed U.S. and European cooperative R&D institutions chartered to consolidate force requirements and bring to bear the efficient application of scientific and technological talent.

INTERNATIONAL COOPERATION IN R&D: HOW CAN IT BE ACHIEVED?

A. Purpose

The purpose of this paper is to examine the key issues which impede the achievement of a broad base of international cooperation in research and development programs.

B. Background

Cooperative R&D programs have been undertaken by the United States and its West European allies in an effort to both strengthen NATO and permit militarily beneficial returns from technical and economic resources. Cooperative efforts range from simple data exchanges through the spectrum of joint development where the United States and one or more allies share responsibility for the overall development of a complete weapons system. For example, on 25 October 1957 the President of the United States and the Prime Minister of Great Britain made a Declaration of Common Purpose:

> Collective defence and mutual help are based on the recognition that the concept of national self-sufficiency is now out of date. The countries of the free world are inter-dependent and only in genuine partnership, by combining their resources and sharing tasks--can progress and safety be found.

The resulting organization, which was established in 1958 and called the Tripartite Technical Cooperation Program (TTCP) (U.S., UK and Canada), was the basis for an enlarged cooperative effort (U.S., UK, Canada, Australia, and New Zealand) formed in 1965 which became one of the principal R&D cooperative agreements for the 70s.

Cooperation between the United States and its other European allies in military R&D began for all practical purposes in 1954 with the establishment of the Mutual Weapons Development Program (MWDP). As a result, multinational technical centers to support NATO technical data exchange programs and multinational R&D programs were established. In 1963, the MWDP was expanded to the Mutual Weapons Development Data Exchange Program (MWDDEP) with the objective of better coordinating the technological capabilities of the United States and its allies, reducing the costs and duplication of development efforts, and advancing the concept of standardization. At the same time, the Defense Development Exchange Program (DDEP) was established to cooperate with U.S. allies in the Far East. Its objectives were similar to those of the MWDDEP.

DOD Directive 3100-3 (also issued in 1963) established policy regarding U.S. cooperation with allies in R&D. The directive stated that the "U.S. will cooperate with its Allies to the greatest degree possible in the development of defense equipment, where such cooperation is in the overall best interests of the Ueited States." The DOD Directive was supplemented by Army, Navy, and Air Force regulations that specified ways and means by which they were to implement their cooperative policies.

In May 1966 the North Atlantic Council revised the NATO organization and procedures to improve its ability as a discussion forum and clearinghouse instituting cooperative projects. A conference of National Armaments Directors was established within NATO to deal with the development and procurement of equipment for NATO forces. In addition, Army, Navy and Air Force Armaments Groups and a Defense Research Group were established as the action bodies to initiate cooperative efforts. DDR&E arranges for U.S. representation at the meetings of the Conference.

By 1972 the principal organizations for sharing R&D knowledge and entering into joint efforts were the Technical Cooperation Program and several science and technology organizations within NATO. The Technical Cooperation Program's major emphasis is in the technology base. This

program is a vehicle not only for the exchange of information but also for reviewing each other's programs, recommending new directions or cooperative programs, and exchanging materials, equipment and test items. It also serves as a vehicle to establish bilateral or multilateral agreements among countries. The United States is now exchanging information on key requirements, capabilities, and decision dates relating to national developments on a regular basis with NATO allies.

C. Statement of the Problem

Despite cooperative efforts, it has been estimated that about $2 billion of U.S. R&D is duplicated by our West European allies. In fact, in the FY74 Senate Appropriations Hearings, Secretary Richardson testified that the duplication had been increasing and DOD had been attempting to find ways to reduce overlap in tactical weapons development. The status of the international cooperative effort as of 30 September 1973 indicates that less than 9 percent of the overlapping expenditures of about $2 billion were being devoted to the cooperative effort.

This problem is exemplified by weapon dissimilarities which sometimes defy the use of a common tactical doctrine with which to deploy forces. In addition, the added burden of multiple logistics and support operations in the event of hostilities encourages Soviet doubts on the viability of the alliance. U.S. leadership in bringing about a more effective technological and tactical coupling between nations of the Western alliance is still urgently needed if the partnership, burden sharing, combined planning, and interdependence aspects of national security policies are to be realized.

Joint military force planning with allies in Western Europe offered the opportunity for the design of a better integrated and more effective NATO force. This type of planning was initiated in the late 1940s and continued to the present day with considerable success. However, the much sought after cooperative effort in defense research and development

has not matured and only an insignificant fraction of total U. S./West European R&D expenditures are used in cooperative ventures. Numerous statements of the essential need for cooperation in this area are announced on both sides of the Atlantic by the highest levels of government without any sizable impact upon program planning or resource conservation.

For political, military, and economic reasons, cooperation between the United States and its allies in defense R&D is highly desirable. From the economic viewpoint, work sharing can preclude the needless and wasteful simultaneous development and procurement of logistically dissimilar weapons in two or more allied countries. Furthermore, work sharing will foster a more comprehensive understanding of the interdependence of the various national economies and will serve to enhance political and economic solidarity at a time when the foundations of the West are trembling.

Very few, if any, official voices are heard that formally denounce or discourage the effort. Thus the issue is not whether to cooperate, but how to set aside the obstacles that constrain progress and waste resources, and move towards a more meaningful and expanded program of activities.

D. Discussion

There are several decisive issues which are currently impacting efforts to foster increased international cooperation in defense research and development. These can be broadly categorized as requirements issues, economic issues, category of cooperation issues, and planning issues. Each of these issues also carries an "on what" and "with whom" consideration since the R&D capability of U.S. allies varies markedly from country to country. The principal problems of the cooperative effort are described below.

1. Requirements Issues

Requirements issues usually stem from difficulties in harmonizing needs and agreeing upon specifications for military equipments. This

problem is usually introduced by the United States stated need to design its forces to serve a broad military role attuned to global threats whereas West European nations generally constrain their military force and equipment developments to those which offset the Warsaw Pact threat. This results in the NATO nations according primary emphasis to the establishment of R&D requirements related to the European terrain, climate, urban/rural peculiarities, and manpower availability. This pervasive problem is based upon the issue of whether the United States should concentrate its resources on developing specialized forces to combat the USSR in Western Europe and minimize R&D requirements for other theaters, or continue to maintain a broadly based developmental posture which continues to encompass an extended concept of possible military contingencies. In stressing flexibility, the United States often builds into R&D efforts a higher degree of technological sophistication than allies believe supportable in terms of resource economy and combat effectiveness. For example, Admiral Hill-Norton, chairman of the NATO Military Committee, noted recently:

> I'd rather see all the Allies equipped with a weapon that was 80% efficient than two or three of them with a weapon that was 100% but that was incompatible with the allies on either side of them.

This attitude is not uncommon on both sides of the Atlantic among those who rate the overall cohesiveness of NATO forces above that of attaining the ultimate efficiency in weaponry by a limited number of allies. Their views center upon the need to enhance the deterrent posture of NATO in a world of diminishing resources by reflecting its often stated political resolve in the building of an integrated military force based on common weapons, tactics, logistics, and maintenance support systems. Technological superiority is often interpreted to mean not only the ability to field a superior weapon, but also the ability to produce it expeditiously, maintain the system effectively in service, and provide a common logistics support team. The counterarguments stem from uncertainties regarding the future viability of the alliance, and from the need for the United States to structure its forces for a wide spectrum of potential conflict.

Additional disagreements which sometimes result in the mismatch of R&D requirements evolve from differing viewpoints on short war vs long war constructs, and offensive vs defensive considerations. The former consideration impacts upon the level of sophistication required by any given weapons system, and consequently upon the essential elements of an R&D requirement such as "meantime between failure," maintainability, and so forth. The latter issue involves a more difficult decisionmaking process since it involves the establishment of a primary requirement. For example, European nations will tend to specify high rate of climb aircraft at the expense of range because of the proximity of the Warsaw Pact forces; the tank vs antitank controversy would also fall into this category of disagreement. These difficulties also tend to center upon the U.S. predisposition to continue R&D toward the development of multipurpose forces, and upon a reluctance to permit a defensive warfare philosophy to dominate the R&D program.

2. <u>Economic Issues</u>

Economic issues involve such considerations as balance of payments, the Buy American Act, and the national employment base. The United States wishes to ensure that offshore purchases which involve cooperative R&D efforts will have a minimal impact upon the defense industry and subsequently on economy. West European nations express less concern than the United States on this issue since their primary concern appears to be centered upon reducing overall R&D and untoward economic impacts upon all parties to the alliance while at the same time maximizing military effectiveness.

Some economic problems tend to be more intractable than others; of these, the R&D programs in engineering development and approaching the production stage of the cycle are the most sensitive. U.S. policy dictates that military weapons and equipment must be procured within the United States; with a notable and recent exception (UK V/STOL aircraft Harrier) this has been the practice for two decades. The result is that although

cooperative R&D efforts can be consummated with allies, their defense industries are not able to participate in the full fruits of production; hence their efforts are inevitably constrained to short production runs. No such restriction is imposed upon the United States by allied countries. Co-production efforts, or tooling transfers, have not always aided the standardization process, since design changes often occur in production and result in a significant equipment dissimilarity which defeats the cooperative objective.

The issues to be resolved in the economic area hinge upon a reevaluation of the weapon or equipment production linkages to R&D cooperative efforts to assess how an equitable distribution of production can be achieved. Similarly, the ongoing engineering development cycles of alled nations could be reprogrammed to result in sufficient "fly before buy" prototypes being made available to permit multinational evaluation and, as necessary, modifications to design prior to procurement. In the event of major disagreement regarding the production version, a modular approach to the design of a final configuration could be adopted to permit variations that fall within acceptable levels of standardization. The United States would then be permitted an opportunity for the limited sophistication of its own equipment to serve additional global commitments. The economic issues of R&D cooperation will yield to any sensible methodology that provides a quid-pro-quo solution. This can be accomplished by shared developmental work and production or by the equalizing of both aspects of the process across the Atlantic over a period of years.

3. <u>Category of Cooperative Issues</u>

The category of cooperative issues revolves around the degree of the emphasis to be placed on cooperative efforts at three levels of the R&D spectrum of activity. The levels are: (1) cooperative efforts in the technology base area which encompasses research (6.1) and exploratory development (6.2), (2) cooperative efforts in the advanced (6.3) and engineering (6.4) phases of development, and (3) cooperative efforts in

the test and evaluation phase of the R&D cycle. In the first area, nations are somewhat reluctant to forego their own mastery of advanced techniques since these projects are of relatively low cost. At the advanced and engineering levels of development, which are also the high R&D cost areas, activities become issue oriented because of differing viewpoints regarding military force scenarios, degree of sophistication required, and who is to take the lead role. Test and evaluation tends to be issue oriented on both test procedures and assessment criteria.

In considering these categories, it is readily apparent that economic consensus or combat scenarios do not tend to dominate the technological base efforts of the allied nations. The issues are more muted and tend to center upon devising appropriate methods by which basic findings can be communicated and shared. These problems are sometimes alleviated by the unclassified nature of much of the work which finds expression in the international scientific, and technical literature. Hence the dominant issue is how to harness the many building blocks of science and technology on a timely basis to keep defense planners aware of progress and to encourage cross fertilization. These relatively low cost basic activities are rarely completely duplicative and even when overlap is discerned, it may be prudent to maintain some parallel activity; data exchanges will normally ease unnecessary financial burdens.

The jointly sponsored cooperative research efforts in this area are few in number and center on such topics as undersea research (including acoustics), aircraft and helicopter dynamics, and materials. Cooperative efforts in the technology base could be strengthened by encompassing a wider range of research activity than is now being undertaken. The issue is how to expand the effort and at the same time ensure that critical gaps are not developed in any country's scientific knowledge since this situation would be generally unacceptable to major nations.

The real key to cooperative R&D is in the advanced and engineering development categories of the cycle, and it is during these phases

that the standardization problem begins and issues arise. Any nation's effort at this point is focused upon a mission-related objective which has been devised from an assessment of the projected threat and an evaluation of the technological component of a needed response. Since the military departments of alliance members often work with differing combat scenarios and strategic forecasts, the requirements for weapons and equipments for support of similar missions tend to mismatch. Reconciling these differences in the engineering development stage becomes extremely difficult and an "off the shelf" purchase at this stage is extremely difficult to consummate. Effective cooperative efforts during or at the close of the advanced development cycle is a key to future standardization. Once projects have entered engineering development, it becomes extremely difficult to negotiate change and consolidate requirements. The advanced development stage of R&D provides an appropriate pause in the progress toward systems deployment, and offers an opportunity for negotiating differences prior to the incurring of heavy cost commitments and inferred production. In addition, cooperative efforts must be based on the resolution of any difference in mission requirements, to preface the entrance to engineering development. Other issues at the completion of advanced development naturally center upon achieving agreement on the selection of contractors, division of international control, test procedures, and prototype requirements.

Test and evaluation cooperation can be a relatively painless method of stimulating joint efforts, even with countries of the developing world, especially when low technology is involved. High technology, however, often imposes a sizable cost burden because of test complexity; this burden may or may not be offset by cooperative funding transfers. Joint or cooperative testing offers an opportunity for allied nations to develop common processes and procedures for evaluating NATO equipment. The issues in this category of the R&D spectrum are concerned with the development of standardization policies and procedures whereby commonality of weapons and equipment can be achieved.

4. Planning Issues

Planning issues stem from five major sources. These are (1) the multilateral vs bilateral approach, (2) the differing planning mechanisms used by the various allied countries, (3) difficulties in coordinating the various planning and implementing organizations associated with cooperative arrangements, (4) the technological capabilities and capacities of the various countries contributing to the integrated R&D program, and (5) the multiplicity of U.S. defense organizations and agencies either directly or peripherally involved in the planning and implementation of cooperative efforts. These five areas of concern are worsened by the current economic problems of the West and by differing viewpoints on the intent and military capability of the USSR and PRC.

Difficulties have been experienced by the Eurogroup, an organization charged with the standardization of NATO equipment in several planning areas. Not least of these are the difficulties of obtaining consensus from the many nations participating in the selection process. The arguments for the multilateral approach are listed below:

- Fosters wider international technological transfer among U.S. allies.
- Taps a wider source of technology.
- Stimulates international standardization of systems and components.
- Can reduce the U.S. total financial participation.
- Can reduce duplication of effort.
- Strengthens the international organization which sponsors the effort.
- Improves the U.S. image in the eyes of its allies.

The disadvantages of the multilateral approach are as follows:

- Multinational organizations are inefficient:
  - Program requirements, objectives, and levels of effort tend to be compromised in obtaining agreements.

- Multinational organizations are cumbersome, slow-moving and delay program execution.

- Reduces the degree to which the United States can exercise control over R&D product. Increases the possibility of compromise of sensitive technologies (cryptography, nuclear weapons, delivery systems, nuclear effects and protection especially electromagnetic pulse, electronic warfare, and others).

- NATO sponsorship may tie RDT&E to an international alliance which may change in alignment or weaken (especially in view of today's potential realignment of the power structure) thus stifling the RDT&E effort.

The differing planning mechanisms used by members of the alliance tend to cause difficulties in coordinating activities as does the proliferation of the government units involved. Issues sometimes evolve from a lack of uniformity in formulating planning requirements and in the levels of responsibility assigned to members of the planning activity. This sets off a secondary chain of approval responsibility that further serves to slow progress and inhibit the joint R&D planning cycle. The U.S. planning system, although cohesive in form, is plagued by a proliferation of actors from various defense organizations and the Services. This tends to result in too little attention being accorded the careful scrutiny of technology base and mission overlap in formulating cooperative efforts. The planning issues evolving from these considerations are of such magnitude that a revitalized and reorganized planning system to form the basis for future cooperative R&D appears essential to its viability.

The need for a concerted effort to organize many of the R&D cooperative functions at the DOD level, and a full-time staff to implement existing policy, would do much to consolidate the present fractionated effort. Once established, the U.S. vehicle for cooperative planning could be used to stimulate comparable organizations within the alliance and improve the dialogue among the NATO nations. Thus, cooperative R&D planning coordinated or consolidated at the highest level of DOD could replace the ad-hoc efforts and, over the long term, provide a sound basis for compatible military, political, and economic strategies.

In considering a bilateral or modified multilateral approach to the furtherance of cooperative R&D efforts, attention must naturally center upon the United Kingdom, West Germany and France whose technological capabilities dominate the European scene. France is the reluctant partner in this group which would tend to suggest emphasis upon tripartite R&D planning (U.S., UK, West Germany) to act as a catalyst to future cooperation. A select number of mission-oriented objectives could provide an appropriate basis for the negotiation of future commonality. Countries with a more limited capability such as Italy, the Netherlands, Belgium, Norway, Denmark, and Canada could be introduced into the planning cycle after the three principals had resolved their weapon or equipment needs. A modular approach might be adopted to permit the introduction of a limited array of requirements options that did not prejudice the basic design.

Outside of NATO, there are other R&D cooperative opportunities for the United States. In the Far East, Japan is the high-technology nation whose cooperation might well be sought by the United States in a revitalized R&D planning arrangement to further both nations' interest. In the Middle East, Israel provides an opportunity for joint "T&E" efforts based on combat experience with modern U.S., allied and adversary weapons. Comprehensive R&D planning with these allies in mutually acceptable areas could do much to recement the various alliances and, over the long term, provide a sound basis for compatible military, political, and economic strategies.

E. Summary of Major Findings

The economic conditions in both Europe and the United States have given renewed impetus to the drive for standardization through the medium of cooperative R&D. The major issues to be resolved are dominated by the need for joint R&D planning, either within a revitalized and decisive NATO organization or trilaterally with the United States, UK, and West Germany. R&D planning with these allies promises to play an important role in the future as resource limitations and the realities of interdependence are

further understood. Planning with the more modestly endowed R&D performers of Europe could be deferred until the principal partners had resolved differences.

Cooperative R&D planning, when appropriately juxtaposed with U.S. technological base and mission planning, could serve as a basis for the reformation of domestic defense R&D plans. As a drive to both military force modernization and economy of effort, a rejuvenated cooperative R&D effort could revitalize the partnership from the base up, strengthen the strategic coupling and force planning activity of the alliance, and militate against the numerical superiority of Soviet forces. The need for a concerted effort to organize many of the R&D cooperative functions at the DOD level, and a fulltime staff to implement existing policy, would do much to consolidate the present fractionated effort. Once established, the U.S. vehicle for cooperative planning could be used to stimulate comparable organizations within the alliance and improve the dialogue among the NATO nations. Thus, cooperative R&D planning coordinated or consolidated at the highest level of DOD could replace the ad-hoc efforts and, over the long term, provide a sound basis for compatible military, political, and economic strategies.

Requirements issues, particularly those involving a degree of sophistication of weapons and equipments, have continued to cause difficulty in harmonizing needs, but the stark realities of the present economic environments are likely to provide an opportunity for alleviating the problem. Further efforts to define the differing levels of sophistication needed for U.S. weapons and equipments serving a global role, as against a more limited European combat scenario, are essential to obtaining resolution of differing R&D requirements. A modular approach to the specification of U.S. weapons and equipments, to facilitate an expansion of systems to serve a world role, offers some promise. The economic issues of R&D cooperation will yield to any sensible methodology that provides a quid-pro-quo solution. This can be accomplished by shared developmental work and production or by the equalizing of both aspects of the process across the Atlantic over a period of years.

Cooperation in the technology base area poses a minimal burden upon most nations in terms of manpower and defense expenditures. More formalized and frequent data exchanges based on a common set of research and exploratory development objectives would do much to avoid wasteful duplication. Effective cooperative efforts during or at the close of the advanced development cycle are a key to future standardization. Once projects have entered engineering development, it becomes extremely difficult to negotiate change and consolidate requirements. The advanced development stage of R&D provides an appropriate pause in the progress toward systems deployment, and offers an opportunity for negotiating differences prior to incurring heavy cost commitments and inferred production.

Recent economic problems have been assessed to determine their impact upon the alliance; one result of this assessment is that a more compelling case can now be made for interdependence in the R&D field. The nations of Western Europe are a major source of scientific and technological advancement and as such are capable of making major R&D contributions to the common security. The R&D resources of the British Aircraft Corp., Messerschmitt-Boelkow-Blohm, and Lockheed Aircraft are a common resource of the alliance; what is missing are appropriately staffed U.S. and European cooperative R&D institutions chartered to consolidate force requirements and bring to bear the efficient application of scientific and technological talent.

DISTRIBUTION LIST

ORGANIZATION	NO. OF COPIES	ORGANIZATION	NO. OF COPIES
ARPA/T10 Advanced Research Projects Agency 1400 Wilson Boulevard Arlington, VA 22209	7		
Defense Documentation Center Cameron Station Alexandria, VA 22314	12		

ORGANIZATION	NO. OF COPIES	ORGANIZATION	NO. OF COPIES